



Appendix A

AECOM Ecological
Surveys 2014

Square Kilometre Array Ecological Assessment



Square Kilometre Array Ecological Assessment

Client: Department of Industry

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Executive Summary

The Department of Industry commissioned AECOM to conduct a flora and vegetation assessment and a fauna assessment for the Square Kilometre Array (SKA) project. The SKA project is located on Boolardy Station and consists of the SKA1-Survey and the SKA1-Low project areas. The SKA1-Survey will comprise 60 dishes and extend from the existing Australian Square Kilometre Array Pathfinder (ASKAP). The SKA1-Low project will include 750 array stations consisting of antennas that are two metres tall.

A single-phase Level 2 flora and vegetation and a Level 1 fauna assessment was undertaken in September 2014 using methods aligned with EPA Guidance Statement 51 and 56 respectively (EPA, 2004a and 2004b). Targeted searches for conservation significant flora and fauna species were conducted for those species identified in the desktop assessment (see Section 3.0) that are considered likely to occur in the project areas. In addition, a preliminary landform assessment was conducted at sample point locations on the Sherwood Land System to assess the soil condition and erosion severity.

A total of 15 vegetation communities were defined and delineated in the project areas including eight on hardwash plains, three associated with granite outcrops and breakaways, and four associated with drainage lines. No Threatened or Priority Ecological Communities were recorded in the project areas. Of the 15 vegetation communities, eight are considered locally significant. These communities support populations of Priority flora species and some are considered locally restricted, particularly within the granite breakaways and outcrops.

Flora and vegetation was sampled systematically from 65 quadrats and species that may be of conservation significance were opportunistically collected. A total of 199 native flora species from 82 genera and 36 families were recorded. In addition, four weed species were recorded. None of the weed species are Weeds of National Significance (WONS) or Declared Pests under the *Biosecurity and Agriculture Management Act 2007*.

No flora species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Wildlife Conservation Act 1986* (WC Act) were recorded or are considered likely to occur in the project areas. Seven species listed by Department of Parks and Wildlife (DPaW) as Priority flora were recorded in the project areas including *Gunnionsia divisa*, *Ptilotus beardii*, *Frankenia confusa*, *Hemigenia tysonii*, *Sauropus* sp. Woolgorong and *Verticordia jamiesonii*. In addition, the Priority 3 species, *Eremophila simulans* subsp. *megacalyx* was recorded in the Murchison Radio-astronomy Observatory (MRO) during previous surveys. Flowering material is required to distinguish the *Eremophila simulans* subsp. *megacalyx* from the other two subspecies in this complex. No flowering material was available at the time of the field survey therefore species identified as *Eremophila simulans* are considered potential Priority 3 species.

The Western Spiny-tailed Skink (*Egernia stokesii badia*), listed under the EPBC Act and the WC Act as Endangered and Vulnerable respectively, was recorded at three granite outcrops. Two of the three outcrops are located in the SKA1-Low and SKA1-Survey project areas. This species could potentially occur at more granite outcrops in the project area. A potential Priority 4 southwest White-browed Babbler was recorded in the SKA1-Survey project area. This species was unable to be confirmed however the likelihood of this subspecies occurring in the project areas is low. In addition, a trapdoor spider was recorded which may potentially be the Shield-backed Trapdoor Spider. This species is listed under the EPBC Act and the WC Act as Vulnerable. A short-range endemic specialist will need to confirm the presence of this species in the SKA1-Low project area from additional surveys.

The granite outcrops, breakaways and boulders present a significant environmental constraint for the SKA project as they provide habitat for the Threatened Western Spiny-tailed Skink and a number of Priority flora populations. Furthermore, the Murchison River and other unnamed major channels provide important drought refuge and habitat linkage corridors.

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1.0 Introduction

1.1 Background

The Square Kilometre Array (SKA) Project is the largest ever international radio telescope project at €1.8B. The SKA project aims to answer five key cosmological questions, using radio waves from across the universe to look back into the cosmic dark ages. As with all big science projects, the SKA project will draw on the skills, experiences and support of 10 countries working collaboratively to construct and operate elements of the SKA project, with the first phase of the project being hosted by South Africa and Australia. Australia will host the SKA1-Survey telescope (SKA1-Survey) and the SKA1-Low Frequency Aperture Array (SKA1-Low).

The SKA1-Survey will incorporate 60 dishes in addition to the existing 36 dishes of the Australian Square Kilometre Array Pathfinder (ASKAP) telescope. The SKA1-Survey is comprised of a core of approximately 2 km diameter and will add density to the existing ASKAP array in the core (up to an additional 18 dishes). Beyond the core there will be 3 spiral corridors comprised of 14 antennas extending to about 40 km from the core.

SKA1-Low is an entirely new array and will consist of up to 750 array stations. Each array station will consist of up to 300 individual “Christmas tree” antennas, each standing approximately two metres tall. The majority of array stations will be in a densely populated core of 1-2 km diameter. Beyond the core there will be three spiral corridors extending to about 30 km from the core.

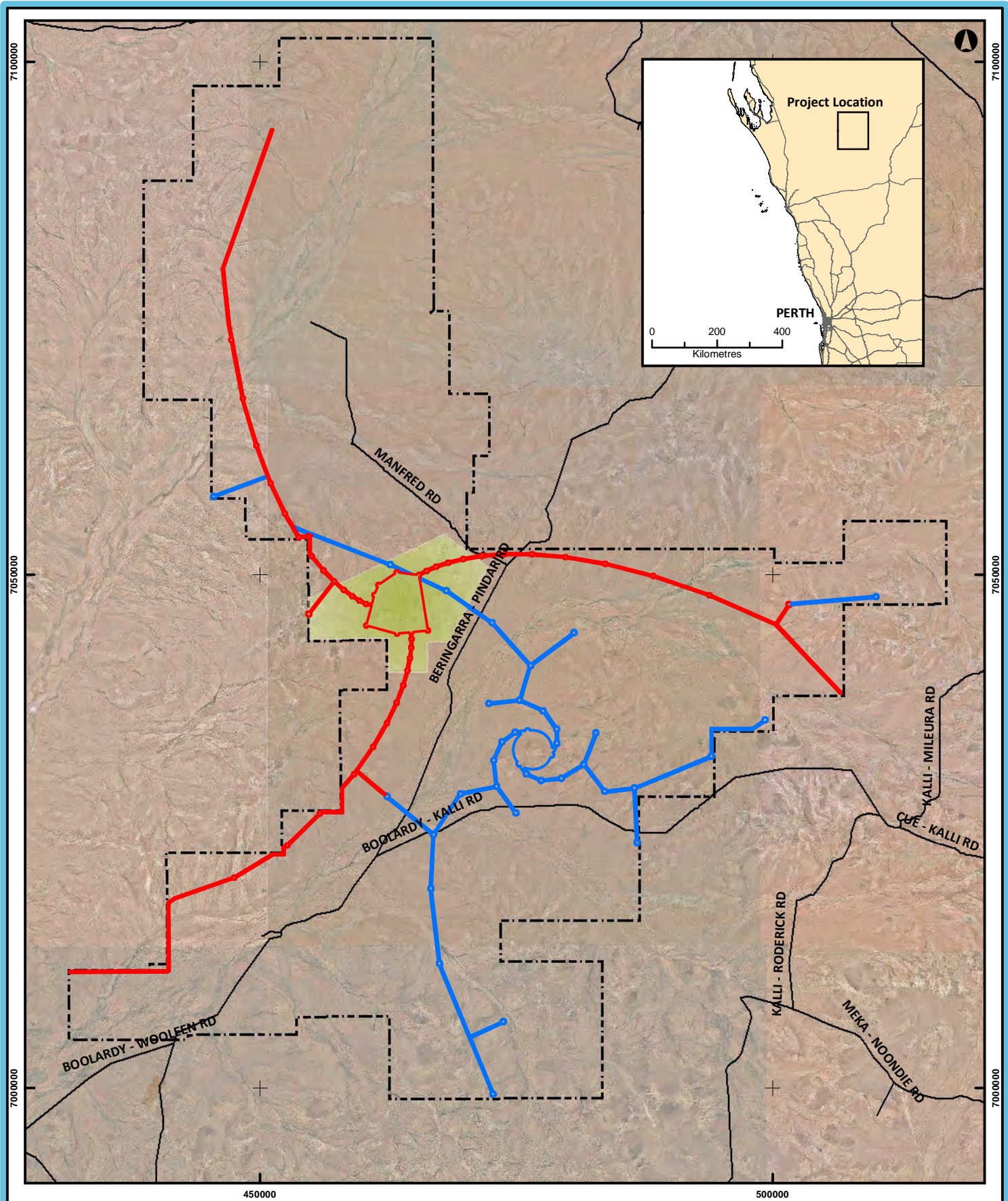
1.2 Location

The SKA1-Survey and SKA1-Low project areas are situated entirely on Boolardy Station in the Shire of Murchison. Boolardy Station is located 250 km northeast of Kalbarri, approximately 570 km north of Perth. The station is accessible via Murgoo-Boolardy Road, Manfred Road, and Cue-Kalli Road.

Figure 1 provides an indicative representation of the proposed configurations of SKA1-Survey and SKA1-Low and includes the outline of the Murchison Radio-astronomy Observatory (MRO) area where the ASKAP telescope has been constructed.

1.3 Objectives

The aim of the flora, vegetation and fauna assessment was to define the ecological values of the SKA1-Survey and SKA1-Low project areas. Significant environmental factors and constraints were targeted in an attempt to quantify conservation significant elements. Data collected was compiled into this technical report, the results of which are presented in a manner suitable for inclusion in environmental approval documentation. The results will be used to inform the ultimate SKA design, environmental impact assessments, and identify environmental factors or areas that require particular management.

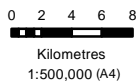


Project Areas

SKA Ecological Survey

Figure 1

Coordinate System: GDA 1994 MGA Zone 50



LEGEND

- ▭ SKA1 - Low
- ▭ SKA1 - Survey
- ▭ Murchison Radio Astronomy Observatory
- Boolardy Station

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2.0 Existing Environment

2.1 Climate

The Shire of Murchison experiences an arid climate with a mean annual rainfall of 190-240 mm (Curry et al., 1994). Rainfall varies significantly depending on the occurrence of sporadic significant rainfall events that are driven by cyclonic weather from the north and cold fronts from the southwest. The summer months are hot and consist of long periods where the temperature exceeds 37.5 degrees Celsius. Winters are cool and sunny with cold evenings and mild days.

The closest weather station to the project area is Meekatharra Airport (station 7045) located approximately 185 km east of Boolardy Station. The rainfall data (Figure 2) shows a significant rainfall event in January 2014 during which 130.6 mm of rain was received at Meekatharra Airport. This was a result of Cyclone Pristine which brought 'drenching' rains throughout the Pilbara and the northern Mid-West. Total annual rainfall to date for 2014 is 172.2 mm which is 28 mm below average (BOM, 2014).

The consecutive months of below average rainfall between June and August prior to the field survey may have implications on the survey results, further discussed in Section 4.0.

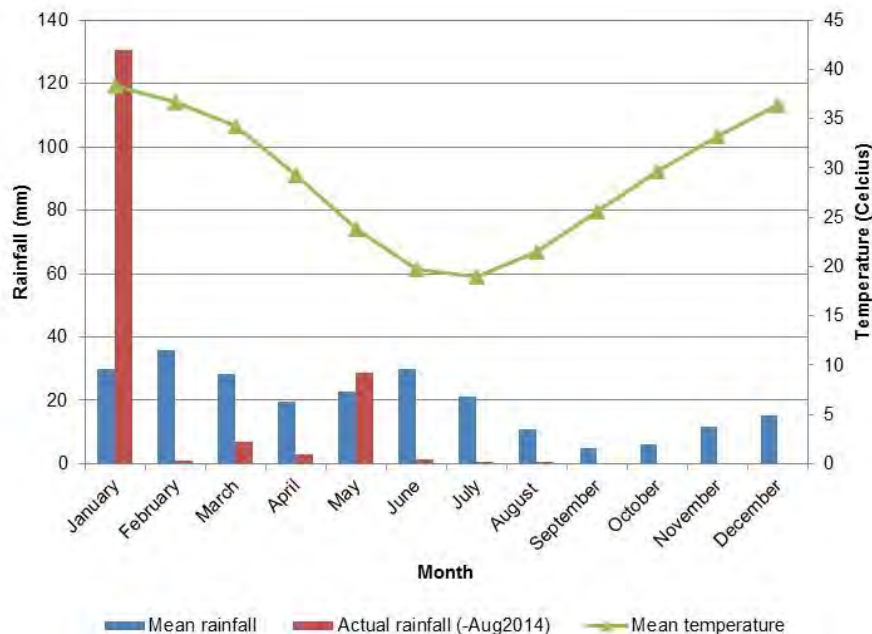
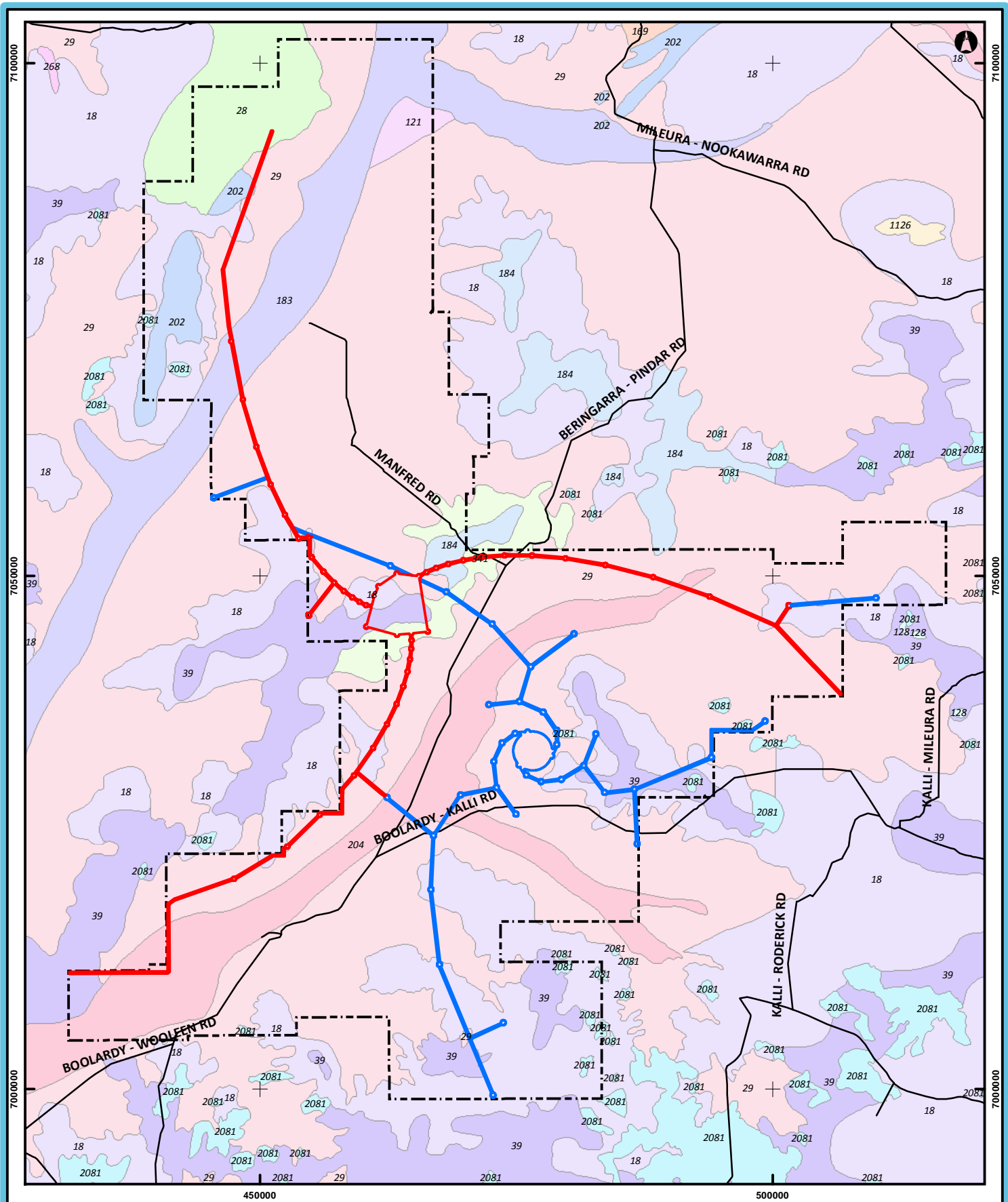


Figure 2 Rainfall and temperature data (average and actual) for Meekatharra airport Station 7045 (BOM, 2014).

2.2 IBRA Region

There are 89 recognised Interim Biogeographical Regions of Australia (IBRA) that have been defined based on climate, geology, landforms and characteristic vegetation and fauna (CALM, 2002). The SKA project is located in the Murchison IBRA bioregion, in the centre of the Western Murchison Subregion. The Murchison bioregion is on the northern part of the Yilgarn Craton which is divided into the Eastern and Western Murchison. There are six wetlands (lakes) of national importance in the bioregion including Ballard, Barlee, Marmion, Wooleen, Breberle and Anneen Lakes.

The Western Murchison subregion, described by Desmond et al. (2001), supports low Mulga woodlands with bunch grasses and ephemerals (annuals). Landscape features include outcrop and extensive fine-textured hardpan washplains. Quaternary sandplains support hummock grasslands, calcareous soils support Saltbush and saline alluvia support *Halosarcia* low shrublands. The subregion contains the headwaters of the Murchison and Wooramel Rivers which drain westwards to the coast. Rare features of the area include calcrete aquifers with short-range endemics, rare fauna, and flora. The land use is predominantly grazing native pastures (96%) and Crown Reserves (2.8%).

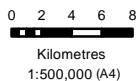


Pre-European Vegetation

SKA Ecological Survey

Figure 3

Coordinate System: GDA 1994 MGA Zone 50



LEGEND

SKA1 - Low	1126	183	268
SKA1 - Survey	121	184	269
Boolardy Station	125	202	28
Vegetation Association (Beard)	128	204	29
1125	169	2081	341
	18	266	39

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2.3 Vegetation

Beard's (1976) vegetation series map for the Murchison region shows nine broad terrestrial vegetation types that occur within the Project areas (Table 1). According to the comprehensive, adequate and representative (CAR) reserve system, the ten vegetation associations each have more than 98% of their original pre-European extent remaining.

Table 1 Beard associations of the project areas

Veg. Assoc.	Description	Area (ha)	
		SKA1-Survey	SKA1-Low
18	Low woodland; Mulga (<i>Acacia aneura</i>)	1,079	865
28	Open low woodland; Mulga	39	0
29	Sparse low woodland; Mulga, discontinuous in scattered groups	2,642	3,105
39	Shrublands; Mulga scrub	1,354	224
183	Low woodland; Mulga, <i>Acacia victoriae</i> & Snakewood	122	0
184	Shrublands; Mulga & Bowgada scrub	86	0
202	Shrublands; Mulga & <i>Acacia quadrimarginea</i> scrub	28	0
204	Succulent steppe with open scrub; scattered Mulga & <i>Acacia sclerosperma</i> over Saltbush & Bluebush	237	265
341	Low woodland over scrub; Mulga over <i>Acacia sclerosperma</i> , Bowgada, <i>A. victoriae</i> & Minnieritchie (<i>A. grasbyi</i>)	606	39
2081	Shrublands; Bowgada and associated spp. scrub	0	41
Total Area (ha)		6,195	4,538

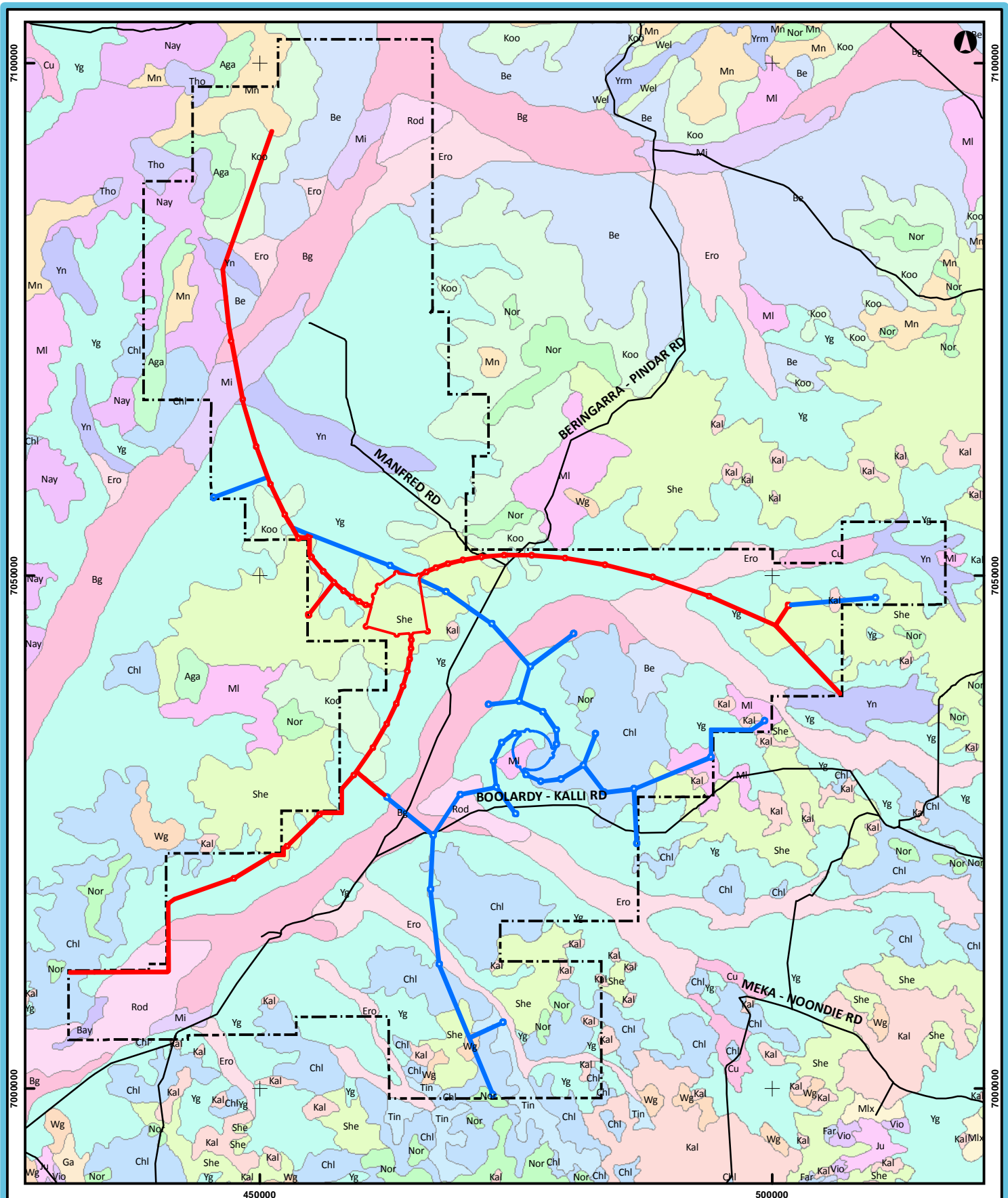
2.4 Land Systems

The mapping of soils, landscapes and vegetation in the Rangelands of Western Australia was conducted in the Wiluna-Meekatharra region in 1963 (Tille, 2006). This became the responsibility of the Department of Agriculture using a procedure developed by the CSIRO. The survey adopted the land system approach, where a land system is defined as an area or group of areas throughout which there is a recurring pattern of topography, soils and vegetation (Tille, 2006).

There are 16 Land Systems that intersect with the SKA1-Survey and SKA1-Low project areas. Descriptions of the 16 land systems and the size of occupancy in each project area are summarised in Table 2.

Table 2 Land Systems of the Project areas

Land System	Description	Area (ha)	
		SKA1-Survey	SKA1-Low
Belele	Hardpan wash plains interspersed by low sandy (Wanderrie) banks supporting tall shrublands of Mulga with understorey shrubs on the hardpan plains and non-saline shrubs with perennial grasses on the banks.	96	0
Beringarra	Major riverine plains with active lower floodplains flanking channelled watercourses; supports mostly halophytic shrublands and mixed <i>Acacia</i> shrublands and low woodlands with minor perennial grasses; severely degraded and eroded in many areas.	93	252
Challenge	Gently undulating gritty-surfaced plains, occasional granite hills, tors and low breakaways, with <i>Acacia</i> shrublands.	48	1,210
Ero	Tributary floodplains with shallow, erodible duplex soils on red-brown hardpan, more or less saline and supporting <i>Acacia</i> shrublands with halophytic and non-halophytic undershrubs; grazed preferentially and widely degraded and eroded.	66	59
Kalli	Elevated, gently undulating red sandplains edged by stripped surfaces on laterite and granite; tall <i>Acacia</i> shrublands and understorey of wanderrie grasses (and spinifex locally); replaced by more extensive areas of Bullimore land system.	0	30
Koonmarra	Quartz-strewn stony plains and low rises with outcropping granite, gneiss and schists; supports scattered Mulga and other mainly non-saline shrubs.	434	0
Mileura	Saline and non-saline calcreted river plains with clayey flood plains interrupted by raised calcrete platforms supporting diverse and very variable tall shrublands, mixed halophytic shrublands and shrubby grasslands.	72	0
Millrose	Level or very gently undulating stony plains on hardpan and granite with irregularly distributed sandy Wanderrie banks, supporting mostly scattered Mulga shrublands with minor Wanderrie grasses.	0	531
Mindura	Low hills, ridges and outcrops of granite, gneiss and quartz above convex, quartz-strewn interfluves and lower plains supporting sparse <i>Acacia</i> shrublands.	6	0
Narryer	Low hills and lateritised breakaways above very gently undulating stony slopes and plains on gneiss and granite with sparse <i>Acacia</i> shrublands.	23	0
Norie	Granite hills with exfoliating domes and extensive tor fields, supporting acacia shrublands.	0	25
Roderick	Broad, saline riverine plains, with numerous grassy drainage foci and claypans adjacent to central alluvial plains and major channels; also non-saline marginal hardpan wash plains; mainly supports halophytic shrublands with minor perennials.	168	85
Sherwood	Breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting Mulga shrublands and minor halophytic shrublands.	2,972	292
Tindalarra	Near level hardpan wash plains, narrow drainage lines and moderately saline drainage floors; supporting tall mixed <i>Acacia</i> shrublands with Wanderrie grasses, also minor Saltbush/Bluebush low shrublands.	0	33
Waguin	Sandplains and stripped granite or laterite surfaces with low fringing breakaways and lower plains; supports bowgada and Mulga shrublands with Wanderrie grasses and minor mixed halophytes.	0	58
Yandil	Flat hardpan wash plains with mantles of small pebbles and gravels; supporting groved Mulga shrublands and occasional Wanderrie grasses.	72	0
Yanganoo	Almost flat hardpan wash plains, with or without small Wanderrie banks and weak grooving; supporting Mulga shrublands and Wanderrie grasses on banks.	2,145	1,963
Total Area (ha)		6,195	4,538

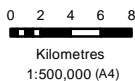


Land Systems (Rangelands)

SKA Ecological Survey

Figure 4

Coordinate System: GDA 1994 MGA Zone 50



LEGEND

	SKA1 - Low		SKA1 - Survey		Boolardy Station
	Agamemnon Land System		Bayou Land System		Belele Land System
	Belele Land System		Beringarra Land System		Challenge Land System
	Bayou Land System		Belele Land System		Cunyu Land System
	Belele Land System		Beringarra Land System		Ero Land System
	Bayou Land System		Belele Land System		Farmer Land System
	Belele Land System		Beringarra Land System		Gabanintha Land System
	Bayou Land System		Belele Land System		Jundee Land System
	Belele Land System		Beringarra Land System		Kalli Land System
	Bayou Land System		Belele Land System		Koonmarra Land System
	Belele Land System		Beringarra Land System		Mileura Land System
	Bayou Land System		Belele Land System		Millex Land System
	Belele Land System		Beringarra Land System		Millrose Land System
	Bayou Land System		Belele Land System		Mindura Land System
	Belele Land System		Beringarra Land System		Narriyer Land System
	Bayou Land System		Belele Land System		Norie Land System
	Belele Land System		Beringarra Land System		Roderick Land System
	Bayou Land System		Belele Land System		Sherwood Land System
	Belele Land System		Beringarra Land System		Thomas Land System
	Bayou Land System		Belele Land System		Tindalarra Land System
	Belele Land System		Beringarra Land System		Violet Land System
	Bayou Land System		Belele Land System		Waguin Land System
	Belele Land System		Beringarra Land System		Weld Land System
	Bayou Land System		Belele Land System		Yandil Land System
	Belele Land System		Beringarra Land System		Yanganoo Land System
	Bayou Land System		Belele Land System		Yarrameedie Land System
	Belele Land System		Beringarra Land System		
	Bayou Land System		Belele Land System		
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2.5 Waterways

The Shire of Murchison contains the Murchison River system including its two tributaries, the Sanford and Roderick Rivers. These rivers only flow after significant rainfall events however there are several permanent pools within the river system including Wooleen and Breberle Lake.

Wooleen Lake is a permanent pool that is located 9 km west of the southern extent of the SKA1-Survey South arm. Breberle Lake is located 52 km west of the SKA1-Survey North arm. Wooleen Lake and Breberle Lake are both listed as Wetlands of National Significance and are recognised as important water bird breeding habitat for *Gelochelidon nilotica* (gull-billed terns) (Desmond et al., 2001). Neither of these two lakes are located on Boolardy Station.

3.0 Methodology

3.1 Desktop Assessment

The desktop assessment involved gathering background information for the local area, restricted to an 80 km radius from the project area centre point (latitude: -26.82097 longitude: 116.76439). A review of relevant literature and databases was conducted, including:

- DPaW Threatened Flora Database
- Western Australian Herbarium (WAH) records
- DPaW Threatened and Priority Ecological Communities database
- Naturemap
- Birds Australia Bird database
- Australian Museum records
- Atlas of Living Australia
- EPBC Act Protected Matters database
- Alexander Holm & Associates (2008) Radio Astronomy Project Environmental Assessment.

All flora and fauna of conservation significance identified in the desktop assessment was assessed for their likelihood of occurrence in the project areas (Table 3). The categories of Threatened and Priority flora are explained in Appendix A.

Available literature was consulted including Beard (1976) vegetation mapping, Land Systems Mapping (Department of Agriculture, 1991), a review of the Western Murchison subregion (Desmond et al., 2001) and environmental studies conducted by Alexander Holm & Associates (2008) for the MRO area. These documents were used to define the existing environment and provide local and regional context for the survey results.

Table 3 Categories of likelihood of occurrence for species of conservation significance identified in the desktop assessment

Category	Flora	Fauna
Likely	Habitat is present in the project areas and it has been recorded in close proximity	Project areas are within the known distribution of the species, habitat is present in the project area and it has been recorded in close proximity previously
Potentially	Habitat may be present in the project areas and/or it has been previously recorded in close proximity	Project areas are within the known distribution of the species, marginal habitat may be present and/or it has been previously recorded in close proximity
Unlikely	No suitable habitat is present and there have been no recorded locations in close proximity to the project areas	Project areas are outside known distribution for that species, or no suitable habitat is present and there have been no recent recorded locations in close proximity to the project areas

3.2 Reconnaissance Survey

A reconnaissance survey was conducted to confirm the desktop assessment findings, traverse the area by vehicle to define access, and conduct preliminary mapping to inform the main field survey. The SKA reconnaissance survey was conducted by Floora de Wit (Senior Botanist) and Matthew Cann (Zoologist) on 12-15 August 2014.

From the reconnaissance survey it was evident that access to the project area was limited. Many tracks were washed-out and overgrown and littered with dead plants and old fencing. The clay soils and shallow broad drainage of the area indicates that many tracks would be unusable after a significant rainfall event.

The findings of the reconnaissance survey included:

- Habitat for *Frankenia confusa* (Priority 2 flora) was identified along the Murchison River within saline clayey flood plains.
- A number of granite outcrops and breakaways were defined and mapped. These provide potential habitat for several Threatened fauna and flora species.
- Lack of recent rainfall had reduced the number of annual species currently present.
- Soil erosion was prevalent on Boolardy Station, with large areas of exposed bare ground, minimal topsoil present, and widespread perennial plant death.

A sample plan was developed based on access tracks and areas of interest that require further targeted surveys.

3.3 Field Survey

The field surveys were conducted by AECOM Senior Botanists Floora de Wit and Gillian Turner with field assistant Lyn van Gorp and Zoologist Matthew Cann. The survey was conducted in September which is considered the ideal time for flora surveys.

The flora, vegetation and fauna assessments were conducted in accordance with the Environmental Protection Authority (EPA) Guidance Notes:

- Terrestrial Surveys for Environmental Impact Assessment in WA (Guidance Statement 51)
- Terrestrial Fauna Surveys for Environmental Impact Assessment in WA (Guidance Statement 56)
- Terrestrial Biological Surveys as an Element of Biodiversity Protection (Position Statement 3).

We have also taken into account and considered implications of the following legislation:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- WA *Environmental Protection Act 1986* (EP Act)
- WA *Wildlife Conservation Act 1950* (WC Act)
- WA *Soil and Land Conservation Act 1945* (S&L Act).

A range of factors discussed in Guidance Statement No. 51 that influenced the design of the survey are presented in Table 4.

Table 4 Factors considered likely to influence the design of the survey

Factor	Methodology
Landform – scale, rarity, heterogeneity	Quadrat locations were selected from review of aerial photography prior to the survey. During the field assessment, vegetation types occurring in the different landforms were ground truthed to determine the accuracy of desktop mapping. The sampling sites were selected based on the variety of land forms present within the Project area.
Habitat – scale, rarity, heterogeneity	Habitats were selected from review of aerial photography prior to the survey. Sites were selected from aerial photography prior to the survey in order to sample the variety of habitats.
Survey of all vegetation units present	Opportunistic relevés were used to supplement the quadrat-based data gathering to ensure all vegetation units present were surveyed and to maximise coverage of the area within the time available.
Conservation significant species	Potential for conservation significant flora and fauna to occur in the project area were based on habitat analysis of conservation significant taxa recorded in the vicinity of Boolardy as defined in Table 4.
Vegetation structure, diversity and seasonality	The survey design was based on establishing quadrats at point sample locations with additional plants collected opportunistically whilst traversing the project area. Species diversity and density was adequately captured in quadrats and opportunistic collections contributed to a comprehensive flora inventory.

3.3.1 Flora and Vegetation

A single phase Level 2 flora and vegetation assessment was undertaken in the SKA1-Survey and SKA1-Low project areas. Point sample locations were visited and a combination of quadrats and relevés completed to document the floristics, community composition, condition, and other identifying features of the area. Sample locations were selected to ensure accurate representation of native vegetation within the project areas. For each survey site a range of parameters was recorded, as detailed in Table 5.

Plants unable to be identified in the field were collected and processed in accordance with the WA Herbarium Standards (WAH, 2008). Species were identified by using taxonomic keys and published species descriptions, further verified by comparing to specimens held at the WA Herbarium. Where appropriate, expertise from DPaW taxonomists was sought out to ensure accurate identification of specimens.

Table 5 Parameters collected at detailed survey locations

Site information	Flora and Vegetation
Date	Species observed
Representative photograph	Height
GPS location	Foliage cover
Soil type	Dominance
Topography / aspect	Weeds
Fire history	Condition based on Keighery (1994)
Weather condition at time of survey	Disturbance

3.3.2 Fauna

The fauna survey was conducted in conjunction with the flora and vegetation survey. Conducting the two assessments concurrently enabled interpretation of the habitat value of each of the vegetation units described and mapped, and determination of each of these as suitable for significant fauna. Where habitat for conservation significant species was located, site details were recorded using Apple iPads with parameters including:

- GPS location
- species observed
- habitats present
- scats
- tracks
- linkage values

In addition to recording all observed fauna and birds identified from distinctive calls, details of indirect evidence such as scats, tracks and diggings was documented. In particular, attention was given to conservation significant species identified in the desktop assessment as having the potential to occur in the area. These included:

- Western Spiny-tailed Skink (Threatened – Vulnerable WC Act and Endangered EPBC Act)
- Shield-backed Trapdoor Spider (Threatened – Vulnerable)
- Malleefowl (Threatened – Vulnerable)
- Australian Bustard (Priority 4)
- Bush Stone-curlew (Priority 4)
- Western Pebble-mound Mouse (Priority 4)
- Rainbow Bee-eater (Migratory and protected under international agreements).

Incidental observations of fauna were recorded whilst traversing the project area. Furthermore, at each habitat, micro habitat searches were conducted. This included raking soil and leaf litter, inspecting dead logs and timber, inspecting burrows, lifting rocks and inspecting loose bark on *Acacia* and Mulga. Bird counts were conducted at each site and were completed within a 2 ha area over 30 minutes. Micro habitat searches and targeted surveys were conducted in the middle of the day when birds were not as active and resulting bird counts would yield fewer results. Bird surveys were conducted in the early morning and late afternoon periods, when birds were most active.

The taxonomy and nomenclature of vertebrate species for mammals, reptiles and amphibians will be conducted in accordance with the Western Australian Museum's Checklist of Vertebrates of Western Australia (WA Museum, 2014) and for bird species the Bird's Australia Checklist of Australian Birds based on Christidis and Boles (2008).

3.3.3 Targeted Searches

Targeted surveys were conducted for conservation significant flora and fauna identified in the desktop assessment considered likely to occur in the project area. Target sites included granite outcrops, breakaways, and saline riverine areas. In these areas, meandering transects were traversed by foot. Where targeted Threatened or Priority Flora species were observed, the following data were collected:

- location using a hand-held GPS
- the number of individuals in the immediate population, or an estimate of the size (number) of the population with an estimated radius of its spatial extent
- plant height
- vegetation condition
- associated dominant species
- soil type and colour
- topography
- additional information relevant to the area including key characteristics and landforms.

3.4 Land System Assessment

A land system assessment was conducted for the Sherwood land system during the field surveys. The field assessment used principles from Landscape Function Analysis methodology to assess the condition. The landform assessment focussed on:

- topography
- rock and geological details
- erosion type and severity
- interpatch size
- rainsplash protection
- perennial vegetation cover
- cryptogram cover
- crust brokenness
- deposited materials
- soil surface roughness.

4.0 Survey Limitations and Comments

Limitations associated with the flora, vegetation and fauna assessments for the SKA project are outlined in Table 6.

Table 6 Field survey limitations

Limitation	Constraint	Impact to survey
Competency/experience of consultant conducting survey	Nil	The survey was conducted by two experienced botanists (more than seven years' experience) and one zoologist. All project personnel have worked in the Murchison bioregion using their respective skills required for the SKA project.
Scope (i.e. what life forms were sampled)	Nil	The flora and vegetation assessment considered all vascular flora species. The fauna assessment considered all terrestrial fauna species excluding subterranean fauna. This is considered suitable for assessing the receiving environment and informing the environmental approval process.
Proportion of flora/fauna identified, recorded and/or collected (based on sampling, timing and intensity)	Minor	The flora and vegetation assessment was conducted during Spring, 2014 and recorded 181 species. Due to lack of significant rain in the time leading up to the survey there is the potential that not all ephemeral species were captured (see Figure 2). Holm (2008) recorded 128 species from a smaller survey area (MRO) and noted that 316 species had been recorded on or nearby Boolardy Station. Fauna in the Midwest region typically respond to significant rain events with an increase in feeding and breeding activity. Leading up to the main survey, isolated patchy rain did fall in some areas which increased fauna activity, particularly reptiles.
Sources of information	Nil	The desktop assessment sources and publicly available material used to inform the survey are predominantly from government databases or published by a government department.
Completion (is further work needed)	Minor	The baseline flora and vegetation assessment identified a number of Priority flora that may require comprehensive pre-clearance targeted surveys. Further short range endemic fauna surveys to confirm the presence of a threatened Trapdoor Spider, <i>Idiosoma nigrum</i> may be required.
Timing, weather, season, cycle	Minor	The field assessments were conducted in late August to September. Timing is considered to rely on rainfall events. With the exception of January, 2014 has received below average rainfall in several consecutive months leading up to the field survey. Because of this it is likely that not all ephemeral species were captured during the field survey. There are no Threatened or Priority ephemeral species that occur in the vicinity of the project area therefore this limitation is considered minor. Isolated patchy rainfall, while not significant, did have a positive short term effect on faunal activity in the region.
Disturbances (e.g. fire flood,	Moderate	Cattle have been present on Boolardy Station since 1883.

Limitation	Constraint	Impact to survey
accidental human intervention) which affected results of the survey		The presence of cattle (and feral goats) and a decline in average rainfall, has resulted in a decline in perennial vegetation. This has led to accelerated soil erosion. The area has patchy perennial vegetation with deflated or no topsoil and exposed inert hardpan remaining as the land surface (Curry et al., 1994). This is discussed at length in Section 5.3.
Intensity (was the intensity adequate)	Minor	The lack of access led to some areas not being traversed during the field survey. For the purposes of assessing the receiving environment the sampling intensity was considered adequate due to the homogenous vegetation communities and availability of good quality aerial imagery. Potential conservation significant fauna habitat was prioritised for sampling. The majority of these habitats were accessed and surveyed for conservation significant fauna.
Completeness (was relevant area fully surveyed)	Nil	The entire project areas was surveyed at the time of this report publication.
Resources (degree of expertise available in plant/animal identification)	Nil	The plant identifications were conducted by Senior Botanist Floora de Wit who has worked in the bioregion previously. The plant identifications were completed at the WA Herbarium. Where necessary, confirmation from DPaw taxonomists was sought for cryptic species or those with limited identifying characteristics. A total of 21 species were submitted to DPaw for identification (including all potential Priority species). Fauna identification to species level was performed in the field where possible drawing knowledge from previous experience in the bioregion and using reference books. Where identification was unable to be performed in the field, a comprehensive inventory of data was made for further analysis in the AECOM Perth office. Scat analysis was performed by Barbara Trigg, based in Victoria.
Remoteness and/or access problems	Minor	Sample point locations were limited to areas where access was possible to the project area (or close to). This limited sampling in some areas of the project area arms. The homogenous nature of the vegetation in the region allowed extrapolation of existing sample sites. Potential conservation significant fauna habitat was prioritised for sampling. Extrapolation was used to classify some areas of non-significant habitat due to poor access. This was not considered a significant constraint due to the homogenous nature of the habitats.
Availability of contextual information on the region	Nil	The Rangelands Survey of the Murchison and Biodiversity Audit for Western Australia was used to determine the local and regional significance of vegetation identified in the project areas.

5.0 Results

5.1 Vegetation

5.1.1 Conservation Significant Communities

There are no EPBC listed Threatened Ecological Communities (TECs) on Boolardy Station. This was confirmed by the EPBC Protected Matters Search report and the DPaW database search. No State-listed TECs were identified in the study area, however, eight Priority 1 Priority Ecological Communities (PECs) have been defined (Table 7).

Table 7 Priority Ecological Communities identified in the desktop review



TEC name	Cons status	Location
Mount Dugel/Mount Narin vegetation complexes (banded ironstone formation).	P1	<1km from SKA1-Survey north arm.
Mount Narryer calcrete groundwater assemblage type on Murchison paleodrainage on Mt Narryer Station.	P1	34km from SKA1-Low north arm.
Meeberrie calcrete groundwater assemblage type on Murchison paleodrainage on Meeberrie Station.	P1	20km west from SKA1-Survey south arm.
Meka calcrete groundwater assemblage type on Murchison palaeodrainage on Meka Station.	P1	11km south from lowest SKA1-Low north arm.
New Forest (including Twin Peaks and Barloweerie Range) vegetation complexes (BIF).	P1	17km south of SKA1-Survey south arm.
Jack Hills vegetation complexes (BIF)	P1	30km east of SKA1-Survey north arm.
Curbur calcrete groundwater assemblage type on Curbur Station.	P1	32km west of SKA1-Survey north arm.
Milly Milly calcrete groundwater assemblage type on Milly Milly Station.	P1	21km northeast of SKA1-Survey north arm.



5.1.2 Boolardy Station Vegetation



No TECs or PECs were recorded in the project area during the field survey. A total of 15 vegetation communities were mapped in the project areas. The vegetation of Boolardy station is comprised predominantly of Mulga (*Acacia aneura* complex species) low woodlands over mixed *Eremophila* and *Senna* species on flat terrain. The landscape is dissected by the Murchison River and an unnamed major channel fringed with *Eucalyptus victrix* and occasional *Melaleuca glomerata*. Smaller drainage channels were characterised by chenopods and *Allocasuarina campestris*. Scattered granite outcrops, domes and breakaways were observed in the south and east arms of the project areas.



Vegetation composition was predominantly low woodland over scattered to isolated tall shrubs over mid to low open shrubland. Some communities consisted of only two strata, lacking low shrubs, herbs and grasses.



Table 8 Vegetation communities recorded in the SKA1-Low and SKA1-Survey project areas



Code	Description	Site details	Photo
Plains			
AaAtPs	<i>Acacia aneura</i> , <i>Acacia pteraneura</i> and <i>Acacia quadrimarginea</i> low open woodland over <i>Acacia tetragonophylla</i> , <i>Eremophila platycalyx</i> and <i>Senna</i> sp. Meekatharra (E. Bailey 1-26) mid to tall sparse shrubland over <i>Pogonolepis stricta</i> , <i>Euphorbia boophthona</i> and <i>Goodenia berardiana</i> low sparse herbland.	<p>Mid-slopes with sandy loam soils adjacent to a granite outcrop. Very Good condition. Associated with the Norie land system. Low numbers of <i>Erodium aureum</i>* present.</p> <p>Species richness: 17 Quadrats: 1</p> <p>Recorded in SKA1-Low south arm</p>	
AfSa	<i>Acacia fuscaeneura</i> , <i>Acacia incurvaneura</i> and occasional <i>Acacia pruinocarpa</i> low open woodland over <i>Senna artemisioides</i> subsp. <i>helmsii</i> , <i>Acacia tetragonophylla</i> and <i>Senna</i> sp. Meekatharra (E. Bailey 1-26) mid to tall sparse shrubland.	<p>Plains, rarely with quarts on the surface. Red clay soils.</p> <p>Species richness: 39 Quadrats: 4</p> <p>Recorded in SKA1-Low core, east and north arms.</p> <p>Supports populations of:</p> <ol style="list-style-type: none"> <i>Eremophila simulans</i> that are potentially the P3 <i>Eremophila simulans</i> subsp. <i>megacalyx</i> <i>Hemigenia tysonii</i> (P3). 	



Code	Description	Site details	Photo
AfEfPo	<i>Acacia fuscaneura</i> , <i>Acacia incurvaneura</i> and <i>Acacia victoriae</i> subsp. <i>victoriae</i> low open woodland over <i>Eremophila forrestii</i> subsp. <i>forrestii</i> , <i>Acacia tetragonophylla</i> and <i>Eremophila phyllopoda</i> low to tall open shrubland over <i>Ptilotus obovatus</i> , <i>Solanum lasiophyllum</i> and <i>Maireana planifolia</i> low sparse shrubland.	<p>Undulating plains sometimes with quarts and granite rocks exposed on the surface. Red sandy clay soils.</p> <p>Species richness: 72 Quadrats: 9</p> <p>Recorded in SKA1-Low core and east arm and SKA1-Survey east, north and south arms.</p> <p>Reflects Alexander Holm & Associates (2008) land unit 5.</p>	
AiAtEf	<i>Acacia incurvaneura</i> , <i>Acacia craspedocarpa</i> and <i>Acacia fuscaneura</i> low open woodland over <i>Acacia tetragonophylla</i> , <i>Acacia kempeana</i> and <i>Acacia oswaldii</i> sparse tall shrubland over <i>Eremophila fraseri</i> subsp. <i>parva</i> , <i>Senna artemisioides</i> subsp. <i>helmsii</i> and <i>Eremophila macmillaniana</i> sparse mid shrubland.	<p>Flat terrain with red clay with a variable soil profile reflecting erosion. Alluvial sands found close to drainage channels transition to clay loams on flats.</p> <p>Species richness: 62 Quadrats: 13</p> <p>Recorded in SKA1-Low core, north and south arms and SKA1-Survey east, north and south arms.</p> <p>Reflects Alexander Holm & Associates (2008) land unit 6.</p>	


Code	Description	Site details	Photo
AiEs	<i>Acacia incurvaneura</i> and <i>Acacia pruinocarpa</i> low open woodland over <i>Eremophila spathulata</i> , <i>Acacia tetragonophylla</i> and <i>Senna artemisioides</i> subsp. <i>helmsii</i> mid open shrubland.	Red clay soils on flat terrain with quarts and iron rocks on the surface. Species richness: 19 Quadrats: 4 Restricted to SKA1-Survey north arm.	
ApAgEf	<i>Acacia pteraneura</i> low woodland to open woodland over <i>Acacia grasbyi</i> and <i>Acacia tetragonophylla</i> tall sparse shrubland over <i>Eremophila forrestii</i> subsp. <i>forrestii</i> , <i>Senna artemisioides</i> subsp. <i>helmsii</i> and <i>Eremophila fraseri</i> subsp. <i>parva</i> mid shrubland.	Undulating flat terrain with red-brown sandy loam soils. Species richness: 48 Quadrats: 8 Recorded in SKA1-Low core and south arms and SKA1-Survey east, north and south arms.	

Code	Description	Site details	Photo
ArEf	<i>Acacia ramulosa</i> var. <i>linophylla</i> low woodland over <i>Eremophila forrestii</i> subsp. <i>forrestii</i> , <i>Ptilotus schwartzii</i> and <i>Eremophila spuria</i> mid to low sparse shrubland.	Alluvial plains of orange sands. Species richness: 12 Quadrats: 2 Recorded on SKA1-Low south arm. Supports populations of: 1. <i>Eremophila simulans</i> that are potentially the P3 <i>Eremophila simulans</i> subsp. <i>megacalyx</i> 2. <i>Sauropus</i> sp. Woolgorong (P1).	
AvEp	<i>Acacia victoriae</i> subsp. <i>victoriae</i> , <i>Acacia sclerosperma</i> subsp. <i>sclerosperma</i> and <i>Acacia tetragonophylla</i> tall shrubland over <i>Eremophila pterocarpa</i> subsp. <i>pterocarpa</i> , <i>Senna</i> sp. Meekatharra (E. Bailey 1-26) and <i>Atriplex amnicola</i> mixed chenopod shrubland	Hardwash plains with red-brown sandy loam clay soils. Species richness: 46 Quadrats: 4 Recorded on SKA1-Low south arm and SKA1-Survey south arm. Supports populations of <i>Gunniopsis divisa</i> (P3).	

Code	Description	Site details	Photo
Granite			
AiTdPb	<i>Acacia incurvaneura</i> , <i>Acacia fusca</i> and <i>Acacia caesaneura</i> low isolated clumps of trees over <i>Thryptomene decussata</i> , <i>Eremophila forrestii</i> subsp. <i>forrestii</i> and <i>Acacia oswaldii</i> mid open shrubland over <i>Ptilotus drummondii</i> , <i>Eragrostis eriopoda</i> and <i>Solanum lasiophyllum</i> low sparse mixed shrub and grassland.	Granite outcrops on undulating terrain. Species richness: 22 Quadrats: 1 Restricted to SKA1-Low east arm. Supports populations of <i>Ptilotus beardii</i> and <i>Verticordia jamiesonii</i> (both P3 species).	
ApTh	<i>Acacia pteraneura</i> and <i>Acacia caesaneura</i> low open woodland over <i>Tecticornia halocnemoides</i> , <i>Eremophila forrestii</i> subsp. <i>forrestii</i> and <i>Eremophila serrulata</i> mid to low open shrubland.	Rocky mid-slopes of quartz below breakaways. Stands of vegetation intermittent with large bare areas. Species richness: 7 Quadrats: 2 Restricted to SKA1-Low south arm.	

Code	Description	Site details	Photo
ArCc	<i>Acacia rhodophloia</i> low open woodland over <i>Corchorus crozophorifolius</i> , <i>Cymbopogon ambiguus</i> and <i>Eremophila platycalyx</i> subsp. <i>platycalyx</i> mixed low to mid shrub and grassland.	Granite domes and boulders with light brown sand loam soils. Also includes <i>Dodonaea viscosa</i> subsp. <i>spathulata</i> and <i>Eremophila latrobei</i> subsp. <i>latrobei</i> . Species richness: 16 Quadrats: 2 Restricted to SKA1-Low east arm. Supports populations of <i>Ptilotus beardii</i> (P3).	
Drainage			
AcAsTd	<i>Allocasuarina campestris</i> low to mid woodland over <i>Acacia sclerosperma</i> subsp. <i>sclerosperma</i> , <i>Exocarpos aphyllus</i> and <i>Scaevola spinescens</i> mid to tall open shrubland over <i>Tecticornia doleiformis</i> , <i>Atriplex amnicola</i> and <i>Tecticornia ?indica</i> mid chenopod shrubland.	Associated with major drainage channels. Exposed granite at some locations. Soils are light red sand to sandy clay. Trees are confined to banks of channels. Species richness: 50 Quadrats: 3 Recorded in SKA1-Low north arm and SKA1-Survey south arm. Supports population of <i>Frankenia confusa</i> (P3).	

Code	Description	Site details	Photo
AiAbSa	<p><i>Acacia incurvaneura</i>, <i>Hakea lorea</i> subsp. <i>lorea</i> and <i>Acacia aneura</i> low open woodland over <i>Acacia burkittii</i>, <i>Acacia tetragonophylla</i> and <i>Acacia victoriae</i> subsp. <i>victoriae</i> tall shrubland over <i>Senna artemisioides</i> subsp. <i>helmsii</i>, <i>Ptilotus obovatus</i> and <i>Senna artemisioides</i> subsp. <i>x sturtii</i> low to mid sparse shrubland.</p>	<p>Undefined broad drainage and flat terrain. Red-brown sandy loam soils.</p> <p>Species richness: 24 Quadrats: 2</p> <p>Recorded in SKA1-Survey east, north and south arms.</p> <p>Reflects Alexander Holm & Associates (2008) land unit 8.</p>	
ArEd	<p><i>Acacia ramulosa</i> var. <i>linophylla</i> and <i>Eucalyptus victrix</i> mid to low woodland over <i>Eragrostis dielsii</i>, <i>Cymbopogon ambiguus</i> and <i>Eriachne pulchella</i> low isolated grassland.</p>	<p>Major defined drainage channels with orange alluvial sands. Channels are bordered with trees and large flat alluvial plains.</p> <p>Species richness: 18 Quadrats: 2</p> <p>Restricted to SKA1-Survey north arm.</p>	

Code	Description	Site details	Photo
EvAsEb	<p><i>Eucalyptus victrix</i>, <i>Melaleuca glomerata</i> and <i>Grevillea nematophylla</i> subsp. <i>supraplana</i> mid to low open woodland over <i>Acacia sclerosperma</i> subsp. <i>sclerosperma</i>, <i>Acacia tetragonophylla</i> and <i>Acacia victoriae</i> subsp. <i>victoriae</i> tall shrubland over <i>Euphorbia boophthona</i>, <i>Marsdenia australis</i> and <i>Pluchea dunlopii</i> low isolated herbs</p>	<p>Major drainage channel (Murchison River) and floodplain. Trees restricted to river banks. River bed is sandy with salt residue on the surface.</p> <p>Species richness: 26 Quadrats: 3</p> <p>Restricted to the Murchison River in SKA1-Survey north arm.</p>	

5.1.3 Previous Assessments

In 2008 environmental surveys were undertaken for the MRO project by Alexander Holm & Associates (2008). The survey identified 11 land units within the MRO, described in Table 9. The table below provides an inference of the existing MRO vegetation mapping and the latest AECOM vegetation communities. A level of confidence (Low, Medium, High) is given based on:

- presence of indicator species
- landform
- soils
- proximity of AECOM community to the MRO.

Table 9 Vegetation communities and fauna habitat defined by Alexander Holm & Associates (2008)

Unit	Broad Description	Vegetation	Fauna habitat	AECOM equivalent vegetation code
1	Sandplains	Supporting very scattered to scattered (Percent Foliage Cover (PFC) 5-20%) tall shrublands of <i>Acacia ramulosa</i> subsp. <i>linophylla</i> , <i>Acacia murrayana</i> , <i>Acacia aneura</i> and Wanderrie grasses (SWGS).	Supporting a high species diversity and abundance of fauna, particularly birds and may support the Australian Bustard and Bush Stone-curlew. Moderate Value.	ArEf Low Few indicator species, same landform and soils.
2	Stripped plateaux edges, residuals and breakaways with short upper footslopes	Supporting isolated to very scattered (PFC <2.5-5%) stunted acacias, <i>Thryptomene decussata</i> and <i>Calytrix divergens</i> .	Many fauna species found on breakaways are habitat specialists and restricted to such areas. These areas may provide nesting habitat for birds (Australian Kestrel, Little Woodswallow, Fairy Martins, Peregrine Falcon), bats, small mammals and specialist reptiles. High Value.	AiTdPb Medium Some indicator species, same landform and soils.
3	Saline lower footslopes below breakaways	Supporting low patchy shrublands or annual herbfields with isolated to very scattered (PFC <2.5-5%) <i>Acacia victoriae</i> , <i>Hakea preissii</i> , <i>Maireana</i> species, <i>Ptilotus obovatus</i> and occasionally <i>Ptilotus beardii</i> (degraded MXHS).	Fragile habitat with highly erodible soils were not known to support any conservation significant fauna. Low to moderate value.	AvEp Medium Several indicator species, similar landform.
4	Low granite hills, domes and Tor heaps	Supporting very scattered (PFC 5-10%) shrublands of <i>Acacia grasbyi</i> , other acacias, numerous low shrubs and occasional grasses such as <i>Cymbopogon ambiguus</i> (RHMS)	A spatially restricted but flora-rich land unit supports habitat-specialist species with restricted distributions. This land unit provides habitat for Western Spiny-tailed Skink and potential habitat for short range endemics. High value.	ArCc Medium Some indicator species, same landform and soils.
5	Non saline stony or gritty surfaced plains	Supporting very scattered to scattered (PFC 2.5-15%) mixed height shrublands of <i>Acacia aneura</i> , <i>Acacia tetragonophylla</i> , <i>Eremophila platycalyx</i> , <i>Eremophila macmillaniana</i> and <i>Senna</i> species and <i>Ptilotus obovatus</i> (GMUS)	This habitat supports sparse low shrubs and limited cover. It is suitable habitat for the Western Pebble-mound mouse that formerly occurred here.	AfPfPo High Directly adjoins this unit.
6	Hardpan plains	Supporting very scattered to scattered (PFC 5-20%) tall shrublands of <i>Acacia aneura</i> , <i>Acacia tetragonophylla</i> and <i>Acacia pruinoarpa</i> with under shrubs <i>eremophila fraseri</i> subsp. <i>parva</i> , <i>Eremophila forrestii</i> and <i>Ptilotus obovatus</i> (HPMS, CRLS).	Habitat for many bird species including the conservation significant Australian Bustard and Bush Stone-curlew. Low to moderate value.	AiAtEf High Directly adjoins this unit, majority of indicator species present.

Unit	Broad Description	Vegetation	Fauna habitat	AECOM equivalent vegetation code
7	Unchannelled drainage tracts	Supporting moderately close to close (PFC 15-50%) tall shrublands of <i>Acacia craspedocarpa</i> , <i>Acacia aneura</i> , <i>Acacia tetragonophylla</i> and low shrubs <i>Eremophila</i> and <i>Senna</i> species, <i>Grevillea deflexa</i> and <i>Ptilotus obovatus</i> (HPMS, CRLS).	This land unit is a small, linear habitat with dense tall acacia shrubland. Drainage lines provide corridors for movement of fauna and provide moderate habitat value. Habitat corridors are discussed in more detail in section 5.5.4.	AiAtEf Medium Majority of indicator species, widespread.
8	Channels and creeklines	Supporting scattered to closed (PFC 10->50%) tall shrublands/woodlands of <i>Acacia aneura</i> , <i>Acacia burkittii</i> , <i>Acacia tetragonophylla</i> with numerous <i>Eremophila</i> and <i>Senna</i> species and some grasses (CRLS).	As in land unit 7, channels and creek lines provide corridors which support movement throughout the landscape. These larger channels provide seasonal pools which provide important refuges for fauna during warm seasons. Moderate to high value.	AiAbSa High Directly adjoins this unit, majority of indicator species present.
9	Gravelly plains	Supporting very scattered (PFC 5-10%) tall shrublands of <i>Acacia aneura</i> , <i>Acacia grasbyi</i> , <i>Acacia pruinocarpa</i> and occasional low shrubs <i>Mirbelia species</i> , <i>Eremophila latrobei</i> subsp. <i>latrobei</i> , <i>Ptilotus obovatus</i> (LACS).	Gravelly plains provide habitat for the Western Pebble-mound Mouse that formerly occurred here. Vegetation cover is sparse however and may not support a high diversity of fauna. Low habitat value.	ApTh Low Similar soils, no indicator species.
10	Quartz ridges with isolated plants along crests, footslopes	Supporting moderately close to close (PFC 20->30%) tall shrublands of <i>Acacia aneura</i> , other acacias and mid height and low shrubs.	Vegetation cover on quartz ridges is sparse with low species richness. Quartz ridges have a moderate value	AiEs Medium Indicator species and soils. Or ApTh Medium Indicator species and soils.
11	Ironstone hills	Supporting very scattered (PFC 2.5019%) tall shrublands with <i>Acacia victoriae</i> , <i>Hakea preissii</i> , other acacias, <i>Eremophila</i> species and occasional <i>Ptilotus beardii</i> .	Vegetation cover on ironstone hills is sparse, with relatively low species richness. No conservation significant species were recorded during the Alexander Holm & Associates (2008) survey. Moderate value.	There were no ironstone hills recorded in the SKA1-Low or SKA1-Survey project area.

5.2 Flora

5.2.1 Floristics

A total of 199 native flora species from 82 genera and 36 families were recorded during the SKA surveys. A breakdown of species collected from both project areas are provided in Table 10. The complete species list is provided in Appendix B.

Table 10 Floristics of the SKA survey areas

Classification	SKA1-Survey	SKA1-Low	Total
Native species	151	127	199
Native genera	67	52	82
Native family	34	25	36
Common native families	Fabaceae (37) Myoporaceae (15) Chenopodiaceae (15) Asteraceae (11)	Fabaceae (32) Myoporaceae (19) Chenopodiaceae (14) Asteraceae (8)	Fabaceae (43) Myoporaceae (25) Chenopodiaceae (20) Asteraceae (14)
Weed species	4	2	6
Weed genera	4	2	6
Weed families	4	2	6

5.2.2 Conservation Significant Flora

No species listed under the EPBC Act or the WC Act were identified during the desktop assessment as occurring in the vicinity of the project areas and none were recorded during the field survey. The desktop review identified 26 Priority species that may occur in the project area including:

- six Priority 1 species
- three Priority 2 species
- 15 Priority 3 species
- two Priority 4 species.

Six Priority flora species and one potential Priority flora species was recorded in the project areas and seven were considered likely to occur as detailed below:

- species recorded
 - *Gunniopsis divisa* (P3)
 - *Ptilotus beardii* (P3)
 - *Frankenia confusa* (P2)
 - *Hemigenia tysonii* (P3)
 - *Verticordia jamiesonii* (P3)
 - *Sauropus* sp. Woolgorong (M. Officer s.n. 10/8/94) (P1)
 - *Eremophila simulans* subsp. *megacalyx* (P3) known from the MRO (Alexander Holms & Associates, 2008)
- likely to occur
 - *Angianthus microcephalus* (P2)
 - *Calytrix verruculosa* (P3)
 - *Eremophila muelleriana* (P3)

- *Goodenia berringbinensis* (P4)
- *Goodenia neogoodenia* (P4)
- *Micromyrtus placoides* (P3).

Furthermore, nine species “May” occur and six were considered “Unlikely” to occur. A comprehensive species list of conservation significant species and their likelihood of occurrence is provided in Appendix C.

***Eremophila simulans* subsp. *megacalyx* (P3)**

Eremophila simulans subsp. *megacalyx* is an erect shrub that grows up to 2 m tall. The branches are erect or spreading and the flowers are purple (Plate 1). This species of three subspecies of *Eremophila simulans*. It is characterised by the outer sepals that are >15 cm long after flowering and are widely ovate to obovata to suborbicular. Lacking flowers, this species cannot be correctly identified with confidence.

Eremophila simulans subsp. *megacalyx* was recorded by Alexander Holms & Associates (2008) in the MRO during the previous field investigations. This species has been elevated to a Priority 3 species since the original survey was conducted. The species was recorded in Land Unit 1, described as supporting very scattered to scattered tall shrublands of *Acacia ramulosa* subsp. *linophylla*, *Acacia murrayana*, *Acacia aneura* and Wanderrie grasses. No location data was available for this species in the report.

Eremophila simulans was recorded at three locations in the project area. This species did not have flowers therefore was not able to be correctly identified to subspecies level. According to Chinnock (2007) the *megacalyx* subspecies is only known from the Nicholson Range near Boolardy Station where it grows in *Acacia* woodlands over *Eremophila forrestii* and *Eremophila simulans*. Location data for the *Eremophila simulans* records have been provided as tentative Priority 3 locations. These are shown in Figure 5.

Table 11 *Eremophila simulans* records in the project area that may be *Eremophila simulans* recorded by AECOM

Latitude	Longitude	No. of individuals	Plant life cycle	Habitat
-26.627241	116.528583	4	Vegetative	Sand on top of clay
-27.07729	116.701922	2	Vegetative	Sandy plain close to breakaways
-26.704501	116.550989	2	Vegetative	Sand rise adjacent to floodplain with uncontrolled drainage channels.



Eremophila simulans subsp. *megacalyx*

Photos: J.D & M.J. Start

Plate 1 *Eremophila simulans* subsp. *megacalyx* (Photo WA Herbarium)

Frankenia confusa (P2)

Frankenia confusa is a low diffuse shrub that grows up to 0.75 m tall. It occurs on wet pale brown sand, brown clay and grey soils on banks of rivers, waterholes and river floodplains. This species is easily mistaken for *Frankenia pauciflora*. Due to the difficulty in correct plant identification in the field, several specimens of potential *Frankenia confusa* were collected, of which only one sample was confirmed as the Priority 2 species.

The record of *Frankenia confusa* was from the SKA1-Survey South arm on the bank of a major well-defined channel (Table 12). The vegetation community was mapped as AcAsTd, with understorey dominated by Chenopod species including *Frankenia setosa* and *Frankenia pauciflora*. Its location is shown in Figure 5.

Table 12 *Frankenia confusa* records in the project area recorded by AECOM

Latitude	Longitude	No. of individuals	Plant life cycle	Habitat
-27.016932	116.362002	20	Flower	Bank of major river channel

Gunnioopsis divisa (P3)

Gunnioopsis divisa is a prostrate annual succulent herb that grows up to 10 cm high (Plate 2). The stems radiate from the base and are fleshy and hairless. The flowers are a pale yellow, fading to white and flowers occur in August. This species is commonly found on colluvial outwash associated with banded ironstone formations.

Nine populations of *Gunnioopsis divisa* were recorded in the SKA1-Survey project area (Table 13). All populations were recorded in community AvEp *Acacia victoriae* subsp. *victoriae*, *Acacia sclerosperma* subsp. *sclerosperma* and *Acacia tetragonophylla* tall shrubland over *Eremophila pterocarpa* subsp. *pterocarpa*, *Senna* sp. Meekatharra (E. Bailey 1-26) and *Atriplex amnicola* mixed chenopod shrubland. The spatial distribution of *Gunnioopsis divisa* is shown on Figure 5.

Table 13 *Gunnioopsis divisa* records in the project area recorded by AECOM

Latitude	Longitude	No. of individuals	Plant life cycle	Habitat
-27.018016	116.402324	2	Flower	Alluvial wash plain
-27.018777	116.402601	10	Flower	Alluvial wash plain
-27.01766	116.387009	10*	Flower	Edge of claypans/winter-wet depression
-27.018455	116.386365	30	Flower	Edge of claypans/winter-wet depression
-27.01857	116.385261	20	Flower	Edge of claypans/winter-wet depression
-27.018149	116.381785	20	Flower	Edge of claypans/winter-wet depression
-27.018914	116.379016	50	Bud, Flower	Edge of claypans/winter-wet depression
-27.01024	116.404484	6	Flower	Clay flats
-27.019154	116.402692	1	Flowers	Clay flats

*Outside project area



Plate 2 *Gunniopsis divisa*

Hemigenia tysonii (P3)

Hemigenia tysonii is an upright shrub that grows up to 0.5 m high with purple-blue-pink/white flowers. This species is commonly found on red sand, sandy clay, lateritic sands on flats, sand dunes and hills.

Hemigenia tysonii was recorded in one quadrat in the SKA1-Low north arm in quadrat LN V01 (Table 14). The vegetation was dominated by *Acacia fuscaneura*, *A. incurvaneura* and *Acacia sibina* over *Thryptomene decussata* and mixed shrubs on a sandy rise adjacent to hardpan clays. The spatial distribution is shown in Figure 6.

Table 14 *Hemigenia tysonii* records in the project area recorded by AECOM

Latitude	Longitude	No. of individuals	Plant life cycle	Habitat
-26.627241	116.528583	2	Vegetative	Clay plains

Ptilotus beardii

Ptilotus beardii is a compact perennial rigid shrub that grows 0.15-0.5 m tall (Plate 3). This species has dark bark on the lower stems and cobweb-like indumentums on young shoots that become glabrescent with age. *Ptilotus beardii* grows on clayey soils, saline flats and low breakaways.

AECOM recorded six populations of *Ptilotus beardii* in the SKA1-Low project area (Table 15). The Alexander Holm & Associates (2008) study found 22,250 *Ptilotus beardii* individuals in the MRO. Populations of *Ptilotus beardii* are shown on Figure 6.

Table 15 *Ptilotus beardii* records in or adjacent to the project area recorded by AECOM

Latitude	Longitude	No. of individuals	Plant life cycle	Habitat
-26.845037	116.89875	200	Flower	Footslope around breakaway
-26.842925	116.90822	500	Flower	
-26.842632	116.90948	500	Flower	Wash plain between granite outcrops
-26.843773	116.904005	5	Flower	
-26.844249	116.899727	100	Flower	Wash off breakaway. Outside of project area.
-26.844584	116.901009	10	Flower	
-26.849117	116.890438	10	Flower	



Plate 3 *Ptilotus beardii*

***Sauropus* sp. Woolgorong (M. Officer s.n. 10/8/94) (P1)**

Sauropus sp. Woolgorong is a shrub that grows up to 1 m tall with yellow flowers (Plate 4). This species' preferred habitat is red sandplains, which is consistent with the two records of this species in the SKA1-Low project area. This species is known from the Western Murchison subregion however was not identified during the desktop assessment. This indicates that there are no known records of this species within 50 km of the SKA project.

Sauropus sp. Woolgorong was recorded at two locations in the SKA1-Low project areas (Table 16). The spatial distribution of *Sauropus* sp. Woolgorong is shown in Figure 6.

Table 16 *Sauropus* sp. Woolgorong records in the project area recorded by AECOM

Latitude	Longitude	No. of individuals	Plant life cycle	Habitat
-27.07729	116.701922	10	Vegetative	Sandy plain close to breakaway
-26.838999	116.91103	200	Vegetative	Red deep sandplain



Plate 4 *Sauropus* sp. Woolgorong

***Verticordia jamiesonii* (P3)**

Verticordia jamiesonii is a short shrub that grows up to 60 cm tall (Plate 5). It has one basal stem and is openly and irregularly branched. The species has tiny leaves, shining red buds, and cream to white flowers with distinct hairs on the stamens, staminodes and style. *Verticordia jamiesonii* grows on sand and clay, sometimes with lateritic gravel in pockets of soil and crevices on weathered, heavy laterite on low breakaways and on rocky hills in open shrublands.

One population of *Verticordia jamiesonii* was recorded in the SKA1-Low project area in vegetation community AiTdPd. Two populations were recorded outside the project area (Table 17). The spatial distribution of *Verticordia jamiesonii* is shown in Figure 6.

Table 17 *Verticordia jamiesonii* records in the project area recorded by AECOM

Latitude	Longitude	No. of individuals	Plant life cycle	Habitat
-26.842649	116.909447	200	Flower	Lateritic breakaway (AiTdPd)
-26.841077	116.915415	40	Flower	Lateritic breakaway, outside project area
-26.834408	116.926339	35	Flower	Rocky outcrop. Outside project area



Plate 5 *Verticordia jamiesonii*

5.2.3 Introduced Species

Four introduced weed species were recorded during the field survey (Table 18). None of these species are Declared Pests under the *Biosecurity and Agriculture Management Act 2007* or Weeds of National Significance. *Erodium aureum* was the most common weed, recorded in eight quadrats.

Table 18 Weeds recorded in the project area recorded by AECOM

Taxon	Common name	DPaW (1999) Weed Status	No of Occurrences	
			SKA1-Survey	SKA1-Low
<i>Erodium aureum</i>	n/a	Moderate	8	4
<i>Lysimachia arvensis</i>	Scarlet pimpernel	TBA	1	0
<i>Brassica tournefortii</i>	Wild Turnip	High	1	0
<i>Sonchus oleraceus</i>	Milk Thistle	Moderate	1	1

5.3 Condition

The condition of the Murchison region was assessed by Curry et al. (1994) by surveying 'condition sites' throughout the region. Patterns of variation existed partially as natural variation but mostly as a consequence of changes related to cumulative impact by grazing animals and pastoral management. The loss of perennial vegetation has led to accelerated soil erosion. The most common forms of erosion are scalding and surface sheeting over 10-50% of the surface. Approximately 42% of vegetated areas are considered to be in poor to very poor condition, 37% was in fair condition and 21% was in good to very good condition (Curry et al., 1994).

The general symptoms are (Curry et al., 1994):

- loss of perennial plant diversity and numbers per unit area
- loss of palatable perennial diversity and density
- general loss of vegetation structure, cover and subsequent denudation
- increases and invasions by unpalatable species such as Prickly Acacia (*Acacia victoriae*) and needle bush (*Hakea preissii*) are common on disturbed or deflated soils
- most widely degraded vegetation types are halophytic shrublands (Saltbush and Bluebush), hardpan Mulga shrubland and calcrete shrubby grasslands.

The field survey showed that the majority of the project areas are considered in 'Very Good' condition. Evidence of disturbance included:

- cattle
- erosion (Plate 6)
- infrastructure (roads and associated culverts, tracks, air strips, fences) (Plate 7 and Plate 9)
- loss of perennial vegetation (Plate 8).

A decline in condition was particularly evident near operational mills and bores. Livestock commonly congregate near these freshwater sources causing soil degradation resulting in the loss of all palatable flora species.

The invasion of unpalatable species was evident with both *Hakea preissii* and *Acacia victoriae* recorded in the project area. *Hakea preissii* was recorded in low numbers at five locations, *Acacia victoriae* was recorded at 17 locations varying from scattered occurrences to being a dominant mid-storey species.



Plate 6 Erosion



Plate 7 Cleared areas



Plate 8 Loss of perennial vegetation



Plate 9 Infrastructure

5.4 Land System Assessment

A preliminary land system assessment was conducted at sample locations on the Sherwood land system. The Sherwood land system is characterised by breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting scattered Mulga shrublands with understorey non-halophytic and halophytic shrubs (Curry et al., 1994). This land system is considered fragile and subject to erosion.

Three types of erosion were observed on the Sherwood land system including:

- **Sheeting:** the progressive removal of thin layers of soil across extensive areas. Sheeting is difficult to detect with assurance and need to be inferred from other soil surface features such as downslope eroded materials or surface nature. Often confused with scalded surfaces but characteristically associated with gradational or uniform textured soils.
- **Rills:** channels cut by flowing water. Rills are initiated by water flowing down sheep or cattle paths. Their presence is a sure sign that water flows rapidly off the landscape, often carrying both litter and soil with it.
- **Scalding:** massive loss of A-horizon material in texture-contrast soils which exposes the A2 or B horizon which are typically hard when dry and have extremely low infiltration rates. Scalds have a productive potential of zero, and pond or shed water readily. They are often on flat landscapes.

Perennial vegetation cover was Low at three of the four sites, with Slight to Moderate cryptogram cover and Slight to Moderate crust brokenness (Table 19). The interpatch size at all locations was considered large, with a high area of bare ground throughout the project area (Plate 10). This is likely a result of long-term grazing and local variability in rainfall. Photos of the landform assessment are provided in Appendix D

Table 19 Landform assessment

Site	Topography	Soils	Erosion	Severity	Interpatch	Rainsplash protection	Perennial veg cover	Cryptogam cover	Crust brokenness	Deposited Materials	Soil surface roughness	Comments
LF1	Midslope	Sandy loam. Red-brown. Dry	Rill	Mod	Large	High	Mod	Slight	Slight	Slight	Low	Slope off breakaway covered with rocky surface of quartz and ironstones. Drainage comes off breakaway causing rill and stream bank erosion. Bare stony interpatches with little build-up of resources.
LF2	Flat, Plains	Sandy loam. Red-brown. Dry	Sheeting	Slight	Large	Low	Low	Mod	Mod	Slight	Low	Wind and water removes sand material from surface. There are few patches to retain resources.
LF3	Flat, Plains	Sandy loam. Red-brown. Dry	Sheeting/scalding	Slight	Large	Low	Low	Mod	Mod	Slight	Low	Potential scalding.
LF4	Midslope	Sandy loam. Red-brown. Dry	Sheeting/Rill	Mod	Large	Low	Low	None	None	Slight	Low	



Plate 10 Sherwood land system 1



Plate 11 Sherwood land system 2

5.5 Fauna

A total of 82 fauna species were recorded during the field survey including:

- 55 birds
- 12 mammals (including 7 introduced species)
- 14 reptiles
- one potential Threatened invertebrate

A comprehensive list of species recorded during the survey is provided in Appendix E.

5.5.1 Conservation Significant Fauna

One threatened fauna species and two potential conservation significant species were recorded during the field survey as below:

- *Egernia stokesii badia* (Western Spiny-tailed Skink), Endangered EPBC Act and Vulnerable WC Act
- *Idiosoma nigrum* (Shield-backed Trapdoor Spider) a potential burrow was recorded
- *Pomatostomus temporalis ashbyi* (White-browed Babbler) a potential Priority 4 subspecies

These records are discussed below and record details are presented in Table 20.

Western Spiny-tailed Skink

The Western Spiny-tailed Skink is listed under the EPBC Act as Endangered and under the WC Act as Vulnerable. Granite outcrops were subject to intense searches during the field survey, during which four pieces of scat were recorded at three granite outcrop locations (Table 20).

The Skink, and evidence of its presence, was recorded at two locations in the SKA1-Low project area on one granite outcrop. In the SKA1-Survey project area a Skink was recorded at one location. The fourth record was from a granite outcrop located south of the MRO originally surveyed by Alexander Holm & Associates (2008). This record was reconfirmed during the field survey where evidence was recorded. This indicates this species' continued survival at this location since 2008.

Shield-back Trapdoor Spider

Potential evidence of the EPBC listed Shield-back Trapdoor Spider was recorded at one location in the SKA1-Low project area (Table 20). This species is listed as Vulnerable under the EPBC Act and the WC Act. The Trapdoor Spider was recorded in the lower saline footslopes habitat, below rocky breakaways.

Further surveys and DNA analysis are recommended to confirm the presence of this short-range endemic species.

White-browed Babbler south west subspecies

A group of White-browed Babblers were recorded in the SKA1-Survey project area (Table 20). The White-browed Babbler south-western subspecies is under protection in WA as a Priority 4 subspecies by DPaW. The subspecies was unable to be determined in the field and would require a specimen collection and further analysis. The record of this species was in the hardpan plain with intermittent sandplain habitat (Figure 5).



Additional species



The desktop assessment identified 28 conservation significant (listed Threatened, Migratory or Priority) fauna species that relate to the SKA project including:

- six species that are likely to occur (described in Table 21), of which the Western Spiny-tailed Skink was recorded and has been discussed previously and has been omitted from the table
- two species that may occur
- twelve Migratory birds species that may visit the area seasonally after rains
- eight species were considered unlikely to occur.

Descriptions and an assessment of likelihood for all species identified in the desktop assessment are provided in Appendix F.

Table 20 Conservation significant fauna recorded during the fauna survey

Species	Evidence	Location			Photo
		Project area	Latitude	Longitude	
<p>Western Spiny-tailed Skink</p> <p>The Western Spiny-tailed Skink belongs to the cunninghamii group; a group of moderately large, rock-dwelling reptiles (Chapple, 2003). Two colour forms exist; the brown form and black form, the latter is delineated from the former by its black colouration, lack of patterning in adults and differing head and scale morphology (DotE, 2014). Western Spiny-tailed Skinks are saxicolous (rock dwelling), occupying rock crevices in large, isolated rocky outcrops, typically granite (Duffield & and Bull, 2002). Occasionally, hollow logs or semi-arboreal habitats are utilised for shelter, with the brown form predominantly occupying York Gum woodland (Chapple, 2003). Crevices occupied by the black form of Western Spiny-tailed Skink are usually identifiable by a “latrine” or scat pile, resulting from regular defecation of all family members, in close proximity to the entrance (Chapple, 2003).</p>	Individual located	SKA1-Survey	-26.69691	117.019238	
	Scat pile located	SKA1-Low	-26.85012	116.889499	

Species	Evidence	Location			Photo
		Project area	Latitude	Longitude	
	Individual located	SKA1-Low	-26.84938	116.889037	
	Scat pile located	200 m south of MRO	-26.72834	116.555373	



Species	Evidence	Location			Photo
		Project area	Latitude	Longitude	
<p>Potential Shield-back Trapdoor Spider</p> <p>The Shield-back Trapdoor Spider is approximately 14mm long and has dark brown to black abdomen and appendages with a yellow to grey abdominal underside. Eyes are arranged in three rows with the two anterior rows possessing two eyes and the posterior row possessing four eyes in a transverse line. A conservation plan (2008-2013) has been published for this species (Avon Catchment Council, 2007). This species typically inhabits heavy clay soils of Eucalypt woodlands and Acacia vegetation and relies on leaf-litter and twigs to build its burrow (TSSC, 2013).</p>	<p>Further surveys to confirm the identity are required</p>	<p>SKA1-Low</p>	<p>-27.06283</p>	<p>116.695426</p>	
<p>Potential White-browed Babbler south-west subspecies</p> <p>The Babbler is a dull brown babbler with a dark eye, white eyebrows and a white throat that shades into brown on the lower underparts. This bird prefers drier scrubby woodlands, Mulga, acacia thickets, mallee, cypress pine scrubs; timber, scrub along watercourses and saltbush communities (Pizzey and Knight, 2007).</p>	<p>Group recorded</p>	<p>SKA1-Survey</p>	<p>-26.96121</p>	<p>116.406765</p>	

Table 21 Conservation significant fauna species considered likely to occur in the project areas

Name	Status	Details
Australian Bustard (<i>Ardeotis australis</i>)	Priority 4 (DPaW)	Once a widespread species, the Australian Bustard is still common in northern Australia and is associated with grassland, spinifex, open scrubland, grassy woodland and burned habitats (Pizzey and Knight, 2007).
Bush Stone-curlew <i>Burhinus grallarius</i>	Priority 4 (DPaW)	This species is known to occur in open woodlands of Mallee and Mulga, grasslands and sandplains, particularly where there is a cover of small sparse shrubs (Morcombe, 2003).
Major Mitchell's Cockatoo <i>Cacatua leadbeateri</i>	Schedule 4 (WC Act)	Major Mitchell's Cockatoo ranges across much of western, central and eastern Australia, utilising timbered watercourses, casuarinas, mallee eucalypts, gibber plains, among other environs. Though widespread, this species is less abundant than other species of white cockatoo (Pizzey and Knight, 2007).
Peregrine Falcon <i>Falco peregrinus</i>	Schedule 4 (WC Act)	A well-known falcon, the Peregrine inhabits a vast array of environs in Australia. Usually uncommon and migratory (Pizzey and Knight, 2007). This species lays its eggs in recesses of cliff faces, tree hollows or large abandoned nests.
Rainbow Bee-eater <i>Merops ornatus</i>	Migratory (EPBC Act); Schedule 3 (WC Act)	The Rainbow Bee-eater is a common species which occupies numerous habitats including open woodlands with sandy loamy soil, sand ridges, sandpits, riverbanks, road cuttings, beaches, dunes, cliffs, mangroves and rainforests. It is possible that this species will occupy open woodland areas within the survey area. The Rainbow Bee-eater avoids heavy forest that would hinder the pursuit of its insect prey (Morcombe, 2003).

5.5.2 Introduced Fauna

Seven introduced fauna species were recorded in the project areas, all of which are listed as Declared Pests under the BAM Act. Species included:

- Camel (*Camel dromedaries*)
- Cat (*Felis catus*)
- Cattle (*Bos Taurus*)
- Dog/Dingo (*Canis lupus* subsp. *familiaris* or *Canis lupus* subsp. *dingo*)
- Goat (*Capra hircus*)
- Horse (*Equus ferus* subsp. *caballus*)
- Rabbit (*Oryctolagus cuniculus*)

Cats, Dogs, Camels, Goats and Rabbits were recorded intermittently in the project area. Dogs were identified through tracks and scats, which were typically common around drainage lines and infrastructure including access tracks. Cattle did not appear to be concentrated in particular areas and signs were widespread. Horses were recorded near the homestead with fewer signs of the species in the project areas.



5.5.3 Fauna Habitats



Eight fauna habitats were delineated and described in the SKA1-Survey and SKA1-Low project areas (Table 22). The most common fauna habitat was the hardpan plain with intermittent sandplain making up, 2845 ha and 92.2% of SKA1-Survey and 3038.4 ha and 69.3% of SKA1-Low. Within this habitat, hardpans can persist for several kilometres. This habitat supports a diverse range of common bird species in the area and some reptiles and Macropods. The habitat is not considered to be significant and is extensive throughout the landscape. Brush-tailed Mulgara may possibly occur in the sandplains within this habitat though the likelihood is low.



The second most common habitat was the non-saline stony or gritty surfaced plains comprising 47.1 ha and 1.5% of the SKA1-Survey and 1,007 ha and 23.1% of SKA1-Low areas. This fauna habitat supports the common species of the area as recorded during the field survey. Historically, the Western Pebble-mound Mouse may have occurred in this habitat and no observations were made during this survey. The delineation of fauna habitats was based on the vegetation mapping and field survey observations by the zoologist.



Habitats considered conservation significant are the channels and creek-line, granite boulders and heaps, and rocky breakaway and plateau edges, which provide habitat for Threatened fauna, locally significant fauna and provide habitat linkages in the landscape.

Table 22 Fauna Habitats of the Project area

Fauna Habitat	Description	Habitat for conservation significant fauna	SKA1-Low area		SKA1-Survey area		Representative Photo
			ha	%	ha	%	
Channels and creek line	Major and minor drainage lines subject to occasional flooding. This habitat provides value to fauna through the use of this habitat as linkages throughout the landscape.	Migratory bird species including the Rainbow Bee-eater; Priority 4 Bush Stone-curlew	20.3	0.5	187.5	6.1	
Granite boulders and heaps	Low hills of emergent granite and rock piles providing water catchment and a relatively high diversity of flora and fauna.	Western Spiny-tailed Skink (Endangered, EPBC act and Vulnerable WC Act)	172.3	3.9	6	0.2	

Fauna Habitat	Description	Habitat for conservation significant fauna	SKA1-Low area		SKA1-Survey area		Representative Photo
			ha	%	ha	%	
Granite domes	Large domes of emergent granite. No value floristically however provides high value for reptiles which seek shelter underneath rocks exfoliated from the surface. Water pools on surface.	None according to the desktop assessment and field survey results.	11.6	0.3	0	0	
Hardpan plain with intermittent sandplain	As hardpan plain with sandplains intermittently traversing the Project area. Sandplains may support Mulgara.	Australian Bustard, Bush Stone-curlew and Brush-tailed Mulgara (all P4)	3,038	69.6	2845	92.2	

Fauna Habitat	Description	Habitat for conservation significant fauna	SKA1-Low area		SKA1-Survey area		Representative Photo
			ha	%	ha	%	
Non-saline stony or gritty surfaced plains	Similar to Hardpan plains, with occasional quarts and stones on surface.	Australian Bustard (Priority 4) and Bush Stone-curlew (Priority 4)	1,007	23.1	47.1	1.5	
Rocky Breakaway and plateau edges	This habitat consists of ferruginised duricrust and weathered granite. It includes steep breakaway faces up to 10 m tall and short rocky upper slopes (Alexander Holm & Associates, 2008).	Shield-backed Trapdoor spider (Endangered, EPBC Act and Vulnerable WC Act); Peregrine Falcon (Schedule 4) High value to other locally significant fauna (Bats, birds of prey)	13.4	0.3	0	0	

Fauna Habitat	Description	Habitat for conservation significant fauna	SKA1-Low area		SKA1-Survey area		Representative Photo
			ha	%	ha	%	
Saline lower footslopes below breakaways	The saline lower footslopes found below breakaways. Vegetation cover is intermittent with large sparse areas common.	None according to the desktop assessment and field survey results.	51.5	1.2	0	0	
Sandplain	Alluvial plains of orange sands. Supports <i>Acacia</i> , <i>Eremophila</i> and <i>Ptilotus</i> species.	Australian Bustard, Bush Stone-curlew, Brush-tailed Mulgara (all Priority 4) Rainbow Bee-eater (Migratory)	49.9	1.1	0	0	
TOTAL Area (ha)			4364	100	3086	100	

5.5.4 Habitat Linkages

Habitat linkages are typically corridors of vegetation that link larger areas of potential fauna habitat. Linkages are important as they enable organisms to move freely between remnant bushland patches, therefore increasing gene-flow between populations. A study conducted by Gilbert *et al.* (1998) found that corridors and/or linkages do maintain species richness in the fragmented landscapes.

The SKA project is located in the Midwest region, where the land use is predominantly grazing native pastures (96%) and Crown Reserves (2.8%). As such, much of the existing habitat is in a non-pristine condition and so linkage corridors remain a valuable asset to local fauna.

Major and minor channels/creek lines intersect both the SKA1-Low and SKA1-Survey a total of 60 times. Not all of these channels necessarily provide habitat linkage. The most valuable linkage corridors occur within the channels and creek line habitat as mapped in Figure 5 and Figure 6.

6.0 Discussion

Boolarly station was established in 1876 and has been used for both sheep and cattle. The impacts of over 100 years of grazing is evident in the loss of perennial (and likely annual flora) vegetation. The composition of vegetation communities appears to be permanently altered as a result of a combination of grazing and drought. This has resulted in the loss of groundcover species and reduced biomass per unit of land. Drought has further exacerbated the problem causing widespread plant death. Condition was therefore overall considered 'Very Good', defined as 'Vegetation structure altered and obvious signs of disturbance. Disturbance caused by repeated fire, aggressive weeds and grazing'. This classification is consistent with the known disturbance in the area. In addition, the area has received below average rainfall in 2014 leading to a decline in plant vigour and health.

6.1 Flora and Vegetation

There are no Environmentally Sensitive Areas, TECS or PECS within in the project areas. Vegetation communities are considered locally significant if they support populations of conservation significant fauna or flora, are restricted to a few locations, or support species that represent a significant range extension. Using these criteria, communities AiTdPb, ApTh, ArCc, AvEp, and AfSa are considered locally significant. Communities AiTdPb, ApTh and ArCc represent granite outcrops, breakaways and boulders in the project area. Populations of two Priority 3 species, *Ptilotus beardii* and *Verticordia jamiesonii* were restricted to exposed granite. Community AfSa supports populations of *Eremophila simulans*, a potential Priority 3 species, and *Hemigenia tysonii* (P3). One population of *Hemigenia tysonii* was recorded in AfSa, comprising of 2 individuals.

Community ArEf is considered locally significant as it supports populations of the potential Priority 3 species *Eremophila simulans*, and *Sauropus* sp. Woolgorong, a Priority 1 species. *Eremophila simulans* subsp. *megacalyx* was recorded by Alexander Holms & Associates (2008) in the MRO during the previous field investigations. This species is only able to be identified when flowering material is present. Three populations of *Eremophila simulans* were recorded during the field investigations, however they were not able to be confirmed to subspecies level due to the lack of flowering material. As a precaution these populations are considered potential Priority 3 locations. A total of eight individuals were recorded from three locations in the SKA1-Survey area. *Sauropus* sp. Woolgorong was recorded at two locations in this community representing 210 individuals.

The Priority 2 species *Frankenia confusa* was recorded on one major channel river bank in the SKA1-Survey South arm. Approximately 20 individuals comprise this population, located in AcAsTd, considered a locally significant community. Several collections of *Frankenia* species were made during the survey but only one sample was confirmed as *Frankenia confusa* with the other samples confirmed as the common *Frankenia pauciflora* and *Frankenia setosa*.

Five populations of *Ptilotus beardii* represented by approximately 1,215 individuals were recorded from in communities ArCc and AiTdPb in the SKA1-Low project area. *P. beardii* habitat includes footslopes around breakaways and wash plains between granite outcrops. One population of 100 individuals was recorded in close proximity to the project area.

One population of *Verticordia jamiesonii* comprising 200 individuals was recorded in the SKA1-Low project area in community AiTdPd. Searches conducted outside the SKA1-Low project area identified an additional two populations of *Verticordia jamiesonii*, comprising of 75 individuals. All populations were recorded on lateritic breakaways. It is likely that further targeted surveys would find more populations of this species outside the project area.

Community AvEp is considered locally significant as several populations of *Gunniopsis divisa* were recorded in this community. A total of 138 individuals from 7 subpopulations were recorded in community AvEp. This species was recorded on claypan edges and alluvial wash plains. One subpopulation, comprising of 10 individuals, were recorded outside edge of the project area. It is possible that this population extends further beyond the boundaries of the project area however further targeted surveys would be required.

6.2 Fauna

The granite boulders and tor heaps support populations of the saxicolous EPBC Act listed *Egernia stokesii badia* (Western Spiny-tailed Skink). *E. s. badia* was located and confirmed at four locations at three granite outcrops. It is expected to occur at other granite outcrops in both the SKA1-Low and SKA1-Survey areas. *E. s. badia* occurs within the granite boulder habitat, which comprises 6 ha of the SKA1-Survey area and 172.3 ha of SKA1-Low area. Combined, habitat for the *E. S. badia* constitutes 2.4% of the total area for both the SKA1-Survey and SKA1-Low. Threats to the black form include degradation/destruction of habitat and increased grazing in habitat areas which increases competition for food.

A Trapdoor was recorded in the SKA1-Low area in the saline lower footslopes habitat below rocky breakaways. The trapdoor closely resembled *Idiosoma nigrum* trapdoor, identified in the desktop assessment as potentially occurring within the Project area. The trapdoor was constructed with a fan of leaves and silk, much like the *Idiosoma nigrum* (TSSC, 2013). Further surveys are required by a short range endemic species specialist to confirm the correct confident identification of this species.

Pomatostomus temporalis ashbyi (White-browed Babbler, Western Wheatbelt subspecies, Priority 4) occurs in south-western Australia in arid and semi-arid zones in Mulga and *Acacia* thickets and scrub, and the shrubland understorey (Gannet and Crowley, 2000) of *Eucalyptus* forests, *Casuarina* woodlands and mallee (Johnstone and Storr, 2004). A family group of *Pomatostomus temporalis* was recorded at one location within the SKA1-Survey area. There is a possibility that the Priority 4 subspecies may occur here as the clinal zone between the northern and southern subspecies is gradual. The lack of other known records in the area indicates that it is unlikely that this species is the Priority 4 subspecies.

Ardeotis australis (Australian Bustard, Priority 4) was not recorded during the survey. It occupies open dry woodlands of Mulga, mallee, heath, tussock grasslands, spinifex, and arid scrub (Morcombe, 2003). It was last recorded in the area in 2009 in the East Murchison region. There have been 17 records of *Ardeotis australis* within an 80 km radius of the centre of the Project areas with 11 occurring within the last 13 years. This species is widespread and can be expected to occur in most habitats however it is more likely to be recorded in the hardpan plain with intermittent sandplain, sandplain and non-saline stony or gritty surfaced plain habitats. These habitats constitute a total of 2892 ha or 93.7% of SKA1-Survey area and 4095 ha or 93.8% of SKA1-Low.

The *Burhinus grallarius* (Bush Stone-curlew, Priority 4) was not recorded during the survey. It occupies woodlands, mallee and Mulga with records scattered across Western Australia. *Burhinus grallarius* has been recorded 29 times within 80 km of the centre of the Project areas. *Burhinus grallarius* prefers groundcover of small sparse shrubs, grass or twig litter in the woodlands, mallee and Mulga scrub it occupies. Suitable habitat for *Burhinus grallarius* within the SKA1-Survey and SKA1-Low are the channels and creek line, hardpan plain with intermittent sandplain, non-saline stony or gritty surfaced plains and sandplain habitats which constitute a total of 3080 ha or 99.8% of SKA1-Survey area and 4115 ha or 94.3% of SKA1-Low. *Burhinus grallarius* is most likely to be recorded in the channels and creek line habitat.

Cacatua leadbeateri (Major Mitchell's Cockatoo, Schedule 4 WC Act) was not recorded in the project area during the fauna survey. *Cacatua leadbeateri* ranges across much of western, central and eastern Australia, utilising timbered watercourses, casuarinas, mallee eucalypts, gibber plains, among other environs. Though widespread, this species is less abundant than other species of white cockatoo (Pizzey and Knight, 2007). This species may occur in most of the habitats of the project area however is most likely to be recorded in the channels and creekline habitat. Given the transient nature of these species and the linear project area, the likelihood of this species persisting in the project area is low.

The *Merops ornatus* (Rainbow Bee-eater, Migratory EPBC Act & Schedule 3 WC act) was identified in the desktop assessment as likely to occur. *Plegadis falcinellus* (Glossy Ibis, Migratory EPBC Act & Schedule 3 WC Act) and *Ardea modesta* (Eastern Great Egret, Migratory EPBC Act & Schedule 3 WC Act) were identified in the desktop assessment as having a high likelihood of occurrence during and following periods of sustained rainfall. These species are widespread and common and are not considered threatened. Other potential seasonal visitors identified in the desktop assessment have not been recorded as frequently in the area, with most records dating back to the 1970's. These bird species may occur, however the likelihood is low.

Fauna habitat of conservation significance are those that are able to support populations of Threatened or Priority species, and those considered critical for the survival of fauna species. Fauna habitat in the project area that can be considered of conservation significance include the rocky breakaway and plateau edges, granite boulders, and channels and creeklines. Other fauna habitats including the sandplains, saline lower footslopes below breakaways, non-saline stony or gritty surfaced plains, and hardpans all potentially provide habitat for

conservation significant species, however these are well represented in the region. The areas of these habitats in the project area are unlikely to provide significant habitat for mobile fauna species.

Habitat linkages are also considered to be of importance in this dry landscape where large bare areas are common. Habitat linkages are typically corridors of vegetation or drainage lines that link larger areas of potential fauna habitat or provide passage through what otherwise represents unsuitable habitat. Linkages are important as they enable organisms to move freely between remnant bushland patches, therefore increasing gene-flow between populations. A study conducted by Gilbert *et al* (1998) found that corridors and/or linkages do maintain species richness in fragmented landscapes. Due to intensive grazing, habitat linkages, in particular drainage lines, provide important refuge for fauna species. The landscape is not expected to be significantly fragmented by the proposed access track and antennae infrastructure. The most valuable linkage corridors occur within the channels and creek line habitat as mapped in Figure 5 and Figure 6.

Drainage communities provide drought refuge and potential habitat linkages. Therefore, communities AcAsTd, ArEd and EvAsEb could be considered of high conservation value. These communities are associated with well-defined large drainage lines however they are unlikely to support fresh water throughout the year therefore drought refuge may be limited. The Murchison River which dissects the SKA1-Survey north arm is a significant refuge for fauna and flora. No antennas are proposed in the vicinity of the Murchison River or floodplain.

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7.0 Conclusions

The following conclusions are made:

- The Threatened fauna species, Western Spiny-tailed Skink, was recorded at three granite outcrops and is expected to occur at more outcrops within the SKA1-Survey and SKA1-Low areas. Similar granite outcrops located on Boolardy Station should be considered as potential habitat.
- A potential Shield-backed Trapdoor Spider was recorded in the SKA1-Low area. Further surveys are recommended to confirm the presence of this species
- Seven Priority flora species were recorded including *Gunniopsis divisa* (P3), *Frankenia confusa* (P2), *Hemigenia tysonii* (P3), *Ptilotus beardii* (P3), *Sauropus* sp. Woolgorong (P1) and *Verticordia jamiesonii* (P3).
- One potential Priority 3 species, *Eremophila simulans*, was unable to be confirmed due to lack of flowering material. This species could represent *Eremophila simulans* subsp. *megacalyx*, which is known to occur in the area.
- Drainage communities AcAsTd, ArEd and EvAsEb may be considered locally significant as they provide limited drought refuge for flora and fauna and limited habitat linkage values
- Locally significant communities include:
 - Granite outcrops, breakaways and boulders, represented by communities AiTdPb, ApTh and ArCc. These communities support Priority flora populations and a Threatened fauna species and should be avoided.
 - Community AvEp. This community was subject to targeted surveys for populations of the Priority 3 flora species *Gunniopsis divisa*, it is likely that there are more populations of *Gunniopsis divisa* outside the project area in similar habitat.
 - AfSa, ArEf, AvEp and AcAsTd. These communities support populations of Priority flora species.

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8.0 References

- Alexander Holm & Associates, 2008. Environmental Assessment - Radio Astronomy Project, Murchison Region, Western Australia. Unpublished report prepared for Department of Industry and Resources.
- Avon Catchment Council, 2007, Shield - backed Trapdoor Spider (*Idiosoma nigrum*) Conservation Plan No. ##. Avon Catchment Council, Western Australia.
- Beard, JS. 1976, *Murchison 1:1 000,000 vegetation series: explanatory notes to sheet 6: the vegetation of the Murchison region*. Nedlands, WA University of Western Australia Press with assistance from the Interim Council for the Australian Biological Resource Study.
- Bureau of Meteorology, 2014. Daily Weather Observations for Meekatharra, Western Australia.
- Department of Conservation and Land Management (CALM), 2002. *Bioregional Summary of the 2002 Biodiversity Audit for Western Australia*. Department of Conservation and Land Management, Perth, Western Australia.
- Chinnock, R.J. 2007. *Eremophila and Allied Genera: A Monograph of the Myoporaceae*. The Botanic Gardens and State Herbarium, Department for Environment & Heritage, Government of South Australia.
- Christidis and Boles, 2008. *Systematics and Taxonomy of Australian Birds*. CSIRO Publishing.
- Curry, P.J., Payne, A.L., Leighton, K.A., Hennig, P., Blood, D.A., 1994, *An Inventory and Condition Survey of the Murchison River Catchment, Western Australia*. Technical Bulletin No. 84. Department of Agriculture, South Perth Western Australia.
- Department of Agriculture, 1991, *Land Systems of the Murchison River Catchment and Surrounds*. Department of Land Administration, Western Australia.
- Department of Conservation and Land Management (CALM), 2002. *Bioregional Summary of the 2002 Biodiversity Audit for Western Australia*. Department of Conservation and Land Management, Perth, Western Australia.
- Department of Environment and Conservation (DEC), 1999. *Weed Strategy for Western Australia*. Department of Environment and Conservation, Perth, WA.
- Department of Environment and Conservation (DEC), 2007. *Banded Ironstone Formation Ranges of the Midwest and Goldfields: Interim Status Report*. DEC, Western Australia.
- Desmond, A Cowan, M Chant, A 2001, 'Murchison 2 (MUR2 – Western Murchison subregion)' in CALM 2002. *Bioregional Summary of the 2002 Biodiversity Audit for Western Australia*. Department of Conservation and Land Management, Perth, Western Australia.
- Desmond, A., Cowen, M., and Chant, A. (2001) A Biodiversity Audit for Western Australia's 53 Biogeographical Subregions in 2002. Murchison 2 (MUR 2 – Western Murchison subregion). Collaboration between the Department of Conservation and Land Management and the Western Australian Museum.
- Environmental Protection Authority, 2002. Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection
- Environmental Protection Authority, 2004a. Guidance for the Assessment of Environmental Factors Western Australia (in accordance with the Environmental Protection Act 1986): Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. No. 51. June 2004.
- Environmental Protection Authority, 2004b. Guidance for the Assessment of Environmental Factors Western Australia (in accordance with the Environmental Protection Act 1986): Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. No. 56. June 2004.
- Environmental Protection Authority, 2013a. Environmental Assessment Guideline for Application of a significance framework in the environmental impact assessment process: Focusing on the key environmental factors. June 2013
- Environmental Protection Authority, 2013b. Environmental Assessment Guideline for Environmental factors and objectives. June 2013
- Environmental Protection Authority, 2013c. Environmental Assessment Guideline for Recommending environmental conditions. September 2013
- Garnett, S.T., & G.M. Crowley 2000. *The Action Plan for Australian Birds 2000*. Environment Australia, Canberra.

- Gilbert, F. Gonzalez, A. Evans-Freke, I. 1998. *Corridors maintain species richness in the fragmented landscapes of a microecosystem*. Published in The Royal Society, 265, 577-582
- Johnstone, R.E. and Storr, G.M. 2004. *Handbook of Western Australian Birds. Volume 2 – Passerines (Blue-winged Pitta to Goldfinch)*. W.A. Museum, Perth.
- Keighery, B.J. 1994. Bushland Plant Survey - A Guide to Plant Community Survey for the Community Wildflower Society of WA (inc) Nedlands WA.
- Pizzey, G., and Knight, F. 2007. *The Field Guider to Birds of Australia*. Ed. P. Menkhorst. HarperCollinsPublishers Australia Pty Ltd.
- Tille, P. 2006, *Soil Landscapes of Western Australia's Rangelands and Arid Interior*. Department of Agriculture and Food, State of Western Australia.
- Threatened Species Scientific Committee. 2013. Commonwealth Conservation Advice on *Idiosoma nigrum* (shield-back trapdoor spider). Accessed on 30 September 2014. Available online at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66798
- Western Australian Herbarium (WAH). 2008. *How to Collect Herbarium Specimens*. Available at: <http://www.dpaw.wa.gov.au/plants-and-animals/wa-herbarium>. Accessed Nov 2014.
- Western Australian Museum, 2014. Checklist of the Terrestrial Vertebrate Fauna of Western Australia, Department of Terrestrial Zoology: Western Australian Museum 49 Kew Street Welshpool WA.